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GRAPE GROWING IN CALIFORNIA

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GRAPE GROWING IN CALIFORNIA

H. E. JACOB[1]

THE CULTIVATED GRAPES of California are mostly of the kind grown in the countries bordering the Mediterranean and referred to as "European" grapes. They are derived from one wild species—*Vitis vinifera*—native to western Asia. Of the cultivated vines in the world more than 90 per cent are pure vinifera. Most of the important varieties cultivated in the remainder of the United States, except Arizona, have been derived from American wild vines or from crosses between them and *V. vinifera*. These are properly called "American" grapes.

California has about 500,000 acres of vineyards, constituting about 80 per cent of the total grape acreage of the United States, but only 3 per cent of the total world acreage. The state produces about 2 per cent of the world's wine, 15 per cent of the world's table grapes, and 30 per cent of the world's raisins.

TYPES OF GRAPES AND THEIR USES

GRAPES are conveniently grouped into four general classes according to the purposes for which they are used: (1) wine grapes, (2) table grapes, (3) raisin grapes, and (4) sweet (unfermented) juice grapes. Any variety can be fermented into a kind of wine, eaten fresh, dried into raisins, or made into sweet grape juice; but each is usually somewhat better suited to one of these purposes than to the others.

WINE GRAPES

Briefly, a wine grape may be defined as a variety known to be capable of producing satisfactory wine in some locality. Dry wines require grapes of high acidity and moderate sugar content; sweet wines, high sugar and low acidity; and in addition quality wines require special characteristics such as those of Riesling, Semillon, and Muscat. These characteristics depend not only on the variety but also on the environment, the best dry-wine grapes being produced in the cooler districts, the best sweet-wine grapes ordinarily in the warmer. Although the texture of the pulp and skin does not affect the quality of the wine, thick skins and firm pulp may reduce the juice yield and increase the difficulty of extraction; whereas thin skins and very soft pulp may increase the care required in harvesting and transporting the fresh grapes. Most good wine grapes are of small or medium size. The best are usually light or moderate bearers.

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TABLE GRAPES

Grapes to be used fresh, either for food or for decoration, are commonly called table grapes. They must appear attractive; must possess good eating, carrying, and keeping qualities; and—to be generally used—must be produced and sold at a relatively low cost.

The tastes of the consumer vary in different markets. Large size, brilliant color, and unusual form are generally appreciated. In American markets, seedlessness is an advantage. Where table grapes must be shipped long distances or stored for considerable periods, firmness of pulp, toughness of skin, and adherence to the stems are important. Excepting the Thompson Seedless (Sultanina), which owes its popularity primarily to its seedless character, all the important table varieties grown in California—Flame Tokay, Emperor, Malaga, Red Malaga (Molinera), and Ribier (Alphonse Lavallée)—have attained their prominence because they possess a better combination of attractive appearance, good eating quality, resistance to injury in handling, and good keeping in storage than any other varieties sufficiently tested under the general cultural and marketing conditions of the state.

The particular combination of characteristics that will render a table grape attractive and successful depends not only upon the variety but also upon the soil and climate. For this reason, certain varieties can be grown profitably only in limited areas. Thus the Flame Tokay does best near Lodi, in the region designated in figure 1 as the intermediate valley region; the Emperor on the east side of the San Joaquin Valley in Tulare and Fresno counties.

To attain the quality of fruit and the quantity of crop necessary for success, table grapes in general require a warm climate and a favorable, but not necessarily highly fertile, soil. Very early varieties are most profitable in the warmest and earliest localities. In the later localities the midseason and late varieties, more attractive in appearance and better in shipping and keeping quality, are preferred.

RAISIN GRAPES

Raisins are essentially dried grapes; yet different varieties and different methods of drying may yield very unlike products, so much so that in other countries a distinction is made between raisins and "dried grapes." Desirable characters in a variety to be used for raisins include (1) soft texture of the dried product; (2) lack of tendency of the raisins to stick together when stored; (3) seedlessness; (4) earliness of ripening; (5) marked, pleasing flavor of the raisins; (6) ease of drying; (7) large or

very small size; and (8) high productivity of the vines. Of the thousands of grape varieties known, only three—Thompson Seedless, Muscat of Alexandria, and Black Corinth (Zante Currant)—are used to make most of the world's raisins. The Thompson Seedless and Muscat of Alexandria are widely grown in the San Joaquin Valley of California, whereas the Black Corinth is grown principally in Greece and Australia and is of only minor importance here.

UNFERMENTED-JUICE GRAPES

For the making of sweet, unfermented grape juice it is necessary, or at least desirable, for the grapes to retain their natural fresh-fruit flavor throughout the processing required to clarify and preserve the juice. In America the juice is most commonly pasteurized after it has been extracted and clarified. Most vinifera varieties when pasteurized by the usual method lose their fresh flavor and acquire an unpleasant cooked taste. Even the strong Muscat flavor changes from that of the fresh grape to one suggestive of Muscat raisins. The strong, "foxy" flavor of certain American varieties, particularly the Concord, comes through the usual processing and pasteurization almost unchanged; hence most of the grape juice made in America is of Concord grapes alone or of Concord blended with other varieties. In certain parts of Europe where the juice is sterilized by close filtration only, followed by bottling under sterile conditions, vinifera varieties are commonly used.

CLIMATIC REQUIREMENTS FOR GRAPE GROWING

Most vinifera grapes need long, warm-to-hot, dry summers and cool winters for their best development. They are not adapted to humid summers, whether temperate or tropical, because of their susceptibility to certain fungus diseases that flourish under such conditions. Neither will they withstand intense winter cold (below 0° Fahrenheit) without protection. Frosts occurring after vine growth starts in the spring may kill most of the fruitful shoots and disastrously reduce the crop. To mature the fruit, a long growing season is needed. Rain during the winter is desirable, though deficiencies can be made up by irrigation. Rains early in the growing season make disease control difficult but are otherwise not detrimental to growth; but rains or cold cloudy weather during the blooming period may cause poor setting of the berries. Rains during the ripening and harvesting periods result in much damage through rotting of the fruit. In relatively cool regions a higher humidity can be tolerated than in warmer regions. Where raisins are to be made by natural sun-drying,

a month of clear, warm, rainless weather after the grapes are ripe is essential.

American grapes—Concord and others—withstand humid summers and cold winters better than pure vinifera varieties. They do better in regions of moderate summer humidity than in the very dry, semiarid climate of the interior valleys of California. Rare, indeed, are the grapes that will endure high humidity coupled with high temperatures, a condition common in the tropics.

TEMPERATURE IN GRAPE GROWING

Vinifera grapes start growth in the spring soon after the daily mean[2] temperature reaches 50° Fahrenheit. Daily mean temperatures of at least 65° are necessary for proper development and ripening of most varieties; and somewhat higher temperatures, 70° to 85°, are needed for some. The time elapsing from blooming to ripening is largely determined for each variety by the effective-heat summation, which, for a given place, is usually calculated by subtracting 50° from the mean temperature for each day[3] and adding together, algebraically, the quantities thus obtained. The result is expressed as degree-days. The earliest varieties require about 1,600 degree-days; the latest, at least 3,500. Beginning the summation of heat at the time of full bloom, Thompson Seedless will be ripe for table use (18° Balling) when the temperature summation above 50° Fahrenheit reaches 2,000 degree-days. This variety will be fully ripe for raisins (25° Balling) when the summation reaches 3,000. Similarly, Tokay will be ripe for table use at about 2,300 and Emperor at about 3,200 degree-days.

It is desirable to have a winter rest period of 2 or 3 months during which the average daily mean temperature is below 50° Fahrenheit, with some freezing but with no temperatures below 0°.

WATER IN GRAPE GROWING

The seasonal amount of water required in growing grapes varies with the temperature and humidity of the air, the depth and water-holding capacity of the soil, the cultural practices, and the kind of grapes. It is lowest in wine-grape vineyards in the cool regions, highest in the late table-grape vineyards grown on shallow soil with a summer covercrop. In

[2] Average of the maximum and minimum temperatures for the day. These can be obtained for many locations from *Summary of the Climatological Data for the United States, by Sections*, published by the Weather Bureau of the U. S. Department of Agriculture, Washington, D. C.

[3] Where whole months are involved it is adequate to multiply the monthly mean temperature, less 50° F, by the number of days in the month.

general the water required increases with (1) the shallowness of the soil, (2) a rise in temperature, (3) the size of the vines, (4) the lateness of maturity, (5) the frequency of application of the water, and (6) the amount of other vegetation in the vineyard. Approximate requirements of available water in various parts of California may be fixed as follows: wine grapes in the coastal valleys, 16–24 inches; wine, raisin, and table grapes in the Sacramento Valley and the intermediate valley region,[4] 24–30 inches; wine grapes and raisins in the San Joaquin Valley, 24–30 inches; table grapes in the San Joaquin Valley and in the hot desert region, 30–48 inches. In the coastal valleys, vineyards are commonly not irrigated, although where additional water can be applied at low cost, irrigation is often profitable. In the interior valleys one should seldom attempt to grow grapes without summer irrigation.

SOILS FOR VINEYARDS

Grapes are adapted to a wide range of soils. In nearly every grape-growing district one finds a preference for certain soil types; and yet in listing all the soils used for growing the various kinds of grapes in the many individual grape-growing regions of the world, one finds a range from gravelly sands to clay loams, from shallow to very deep, and from low to high fertility. Very heavy clays, very shallow soils, poorly drained soils, and soils containing relatively high concentrations of salts of the alkali metals or of boron, or other toxic substances are avoided. The deeper and more fertile soils generally produce the heaviest crops and are generally preferred for raisins, common wine-grape varieties, and some table grapes. Certain wine and table-grape varieties attain higher quality when grown on soils of limited depth and fertility.

VITICULTURAL REGIONS OF CALIFORNIA

Grapes can be grown in California wherever the soil and water conditions are favorable, except at high elevations or near the coast where the temperatures are too low. Certain sections, however, are better adapted than others for certain kinds of grape growing. The differences result principally from variations in temperature, rainfall, and atmospheric humidity—factors influenced by latitude, by elevation, by the ocean, and by the mountains. Lower temperatures tend to prevail northward, and near the coast, and at higher elevations. The coastal influence is greatly modified by the position and height of the coast ranges. In general, rain-

[4] See pages 8–11 for descriptions of these regions.

fall tends to decrease as we go southward or descend the Sierra Nevada foothills or approach the west side of the Great Valley and the easterly slopes of the coast ranges. Atmospheric humidity and fogs decrease as we depart from the coast or go southward.

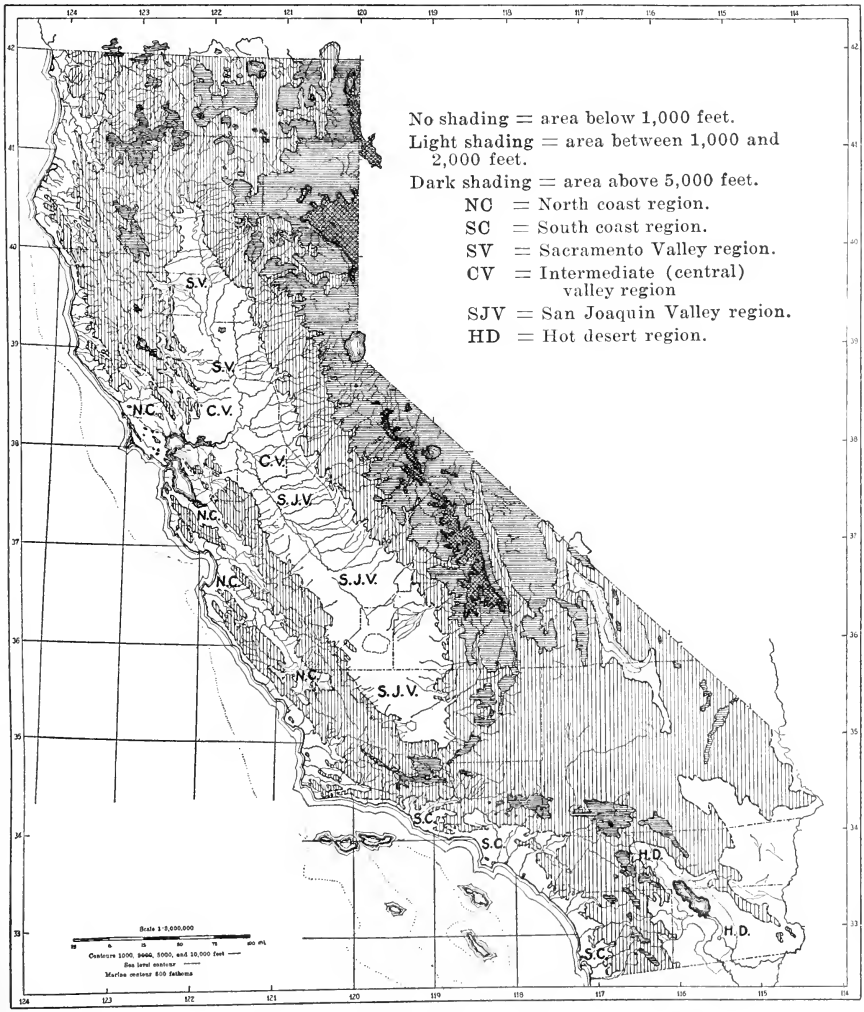


Fig. 1.—The grape-growing regions of California. (From Ext. Cir. 30.)

The variations in climate caused by various combinations of these factors make it possible to divide the grape-growing area of California into several regions distinct at their centers, but intergrading from one to the other: (1) the north coast, (2) the south coast, (3) the Sacramento Valley, (4) the intermediate (central) valley region, (5) the San Joaquin Valley, and (6) the hot desert. (See map, fig. 1.)

THE NORTH COAST REGION

The north coast region comprises the valleys between the coast ranges that roughly parallel the ocean shore, and also the lower slopes of these ranges. Though the largest vineyard areas are found in Mendocino, Sonoma, Napa, Alameda, and Santa Clara counties, there are also notable areas in all the counties abutting on San Francisco Bay. Practically no grapes are grown close to the ocean, where coastal fogs and low average temperatures prevail during the summer.

In summer this area is cooler than the interior valleys. Rainfall varies from 14 inches in the Livermore Valley of Alameda County to over 40 inches in parts of Sonoma and Mendocino counties. Irrigation is not common, although profitable in some areas where water is available at low cost.

The north coast region is primarily one for producing dry wines. The soils and climate are well suited to dry-wine grapes, but one must choose the varieties carefully in order to utilize the natural advantages of each locality. Heavy-yielding varieties for producing ordinary wines should be planted in the fertile valley soils in the warmer areas, not on the rolling lands, which are less productive. On the other hand, the varieties capable of producing fine wines are usually less vigorous and less fruitful, and attain their highest state of perfection on the slopes and in the cooler areas, not in the rich valley soils. With wines, unfortunately, heavy yields and fine quality seldom go together.

No commercial raisins are produced in this section, and table grapes are grown only for home use or for local markets.

THE SOUTH COAST REGION

In southern California the main grape-growing area at present lies around the junction of Los Angeles, Riverside, and San Bernardino counties. At one time Orange County and the westerly half of Los Angeles County contained more vines than all the rest of California. Now, in most of this area the grapes have been replaced by citrus fruits, walnuts, vegetable crops, and suburban homesites. Although a few table grapes are produced for the local markets, the main crop is wine grapes. The climate closely resembles that of the intermediate valley region.

THE SACRAMENTO VALLEY

Northern California contains a great interior valley over 400 miles long and from 50 to 75 miles wide, stretching from Redding to Bakersfield. The northerly part of this great body of agricultural land is called the

Sacramento Valley; the southerly part is the San Joaquin Valley; and the middle part, from Sacramento to Modesto, may be conveniently called the intermediate valley region. This Great Valley with its three parts is protected on the east by the Sierra Nevada, from the wintry blasts of the north by the Siskiyous, and from the cool summer fogs of the ocean by the Coast Range running parallel to the ocean shore.

Northward through the Sacramento Valley the influence of the sea breezes gradually diminishes, while the seasonal summation of heat increases, reaching about 4,800 degree-days at Chico, or nearly the same as at Fresno. The rainfall also increases from 18 inches at Sacramento to about 24 inches at Chico and 36 inches at Redding. Less irrigation is needed than in the San Joaquin Valley. Grape growing in this region has been less developed than farther south. Because of more frequent and earlier autumn rains, the hazard of sun-drying raisins is greater than in the San Joaquin Valley. Sweet-wine grapes, however, do very well; and as the markets for California wines expand, the Sacramento Valley may rival the San Joaquin as a sweet-wine-producing region. It is too hot for most dry-wine grapes. The occasional strong north winds make most of the west side of the Valley unsuited to table grapes, though some of excellent quality are grown in sheltered locations on the east side and at the lower end of the Valley.

THE INTERMEDIATE VALLEY REGION

This region, the coolest of the great interior valleys, has a moderate rainfall of 14 to 20 inches, a moderate effective temperature summation of about 3,750 degree-days for the entire season. It is kept relatively cool by the sea breezes that pass through the gap in the coast ranges near the Golden Gate. Here the brilliant Flame Tokay table grape most nearly reaches perfection. The region also has more limited areas of several other commercial table grapes and large areas of heavy-producing vineyards of wine grapes.

THE SAN JOAQUIN VALLEY

Southward through the San Joaquin Valley, the average temperature increases, becoming more favorable for varieties that need abundant heat. Near the center of the valley at Fresno the effective seasonal summation of heat is about 4,900 degree-days. The annual rainfall, on the other hand, decreases gradually from about 14 inches in Stanislaus County to 4 or 5 at the southern end. In all parts, therefore, irrigation is necessary for the best results. This is the region where a large part of the world's raisins are grown.

Excepting the Flame Tokay, which is principally produced in the intermediate valley region and the very early grapes of the hot desert, most of California's table grapes come from the San Joaquin Valley. They are grown mainly in the eastern half of the Valley in Fresno, Tulare, and Kern counties.

The San Joaquin Valley also produces large quantities of wine grapes which, being high in sugar and low in acid, are well suited for sweet but not for dry wines.

THE HOT DESERT REGION

The Imperial and Coachella valleys, although lying in the Colorado Desert, are no longer barren since the bringing of water from the Colorado River and the installation of wells and pumps in certain areas not supplied with river water. This, the hottest grape-growing region of California, produces the earliest grapes, principally Thompson Seedless and Malaga. Raisins are not made, because the early table grapes ripening in June and early July are more profitable. The high seasonal temperatures, rarely below a daily mean of 50° Fahrenheit, and the scanty rainfall are not ideal for grape growing. Yields are low, and costs of production high. Because of their earliness, however, the table grapes of the hot desert occupy a prominent place in the viticultural industry.

ESTABLISHING THE VINEYARD

A happy combination of locality, variety, cultural methods, and proper utilization of the crop is essential to success. A prospective grower may start in one of two ways: (1) He may have a tract of land on which he wishes to grow grapes. Then he must determine the type of grapes, the varieties most likely to succeed, and finally the cultural methods applicable. (2) He may wish to grow a certain type of grape or perhaps even a certain variety. In this case he should choose the location and adopt the cultural practices apparently best suited to his purposes. In obtaining this information "experience is the best teacher." Lacking experience himself, a prospective grower may consult his local county farm advisor, agricultural commissioner, other successful growers, and available literature. Publications of recent date should be preferred, since recommendations change as more information is made available. It is usually safest to plant a variety already successful in the district. The planting of a new variety in an old grape-growing district or of any variety in a new district must be considered experimental and should usually be done at first only on a small scale.

In addition, important specific conditions to be considered are climatic

factors, such as temperatures, winds, frosts, and rainfall; topography, depth, texture, and fertility of the soil; availability and cost of water for irrigation; roads and distance to winery, packing shed, or shipping point; and sources of labor and supplies.

PREPARATION OF THE SOIL

Before planting, the land should be cleared of trees, stumps, large stones, noxious weeds, and rodent pests. If irrigation is possible, the land should be leveled or graded properly. It should then be well plowed 8 or 10 inches deep; and if a plow sole or other hard substratum is present that can be economically broken up, subsoiling is advisable. A well-developed hardpan cannot usually be broken up with a subsoiler; but if only small areas are encountered, blasting may be feasible. The surface of the soil need not be pulverized and compacted, as for a seedbed, but should be freed from large clods that might interfere with the use of the planting line and with the actual planting.

PLANTING STOCK

One-year-old rootings of the desired fruiting variety should be used in planting a vineyard in any location except where the presence of phylloxera or heavy infestation of nematodes requires the use of special resistant rootstocks.[5] Nearly the whole north coast region and parts of the Sacramento and San Joaquin valleys and of the intermediate valley region are infested with phylloxera. Within such areas one should plant only grafted vines or rootings of rootstocks resistant to phylloxera which are later to be budded or grafted to the desired fruiting variety.

PLANTING PLAN

In planning the vineyard, one should determine the location of the roads, avenues, and irrigation ditches as well as the spacing and arrangement of the vines. The roads and avenues should be wide enough, 16 to 24 feet, to allow the passage of implements and trucks; near enough together to obviate long unnecessary hauls or hand-carrying; and so arranged that they do not interfere with irrigation. The avenues will divide the area into blocks, preferably equal in width to the length of the irrigation furrows. This should usually be from 300 to 600 feet, according to the nature of the soil, the distance increasing as the soil is heavier. If it is longer, intermediate avenues should be left.

The distance between vines will depend on the soil, the climate, the variety, and the methods of pruning and cultivation. In fertile soils and

[5] See pages 61–63.

hot climates, where the vines grow large, each vine should have about 100 square feet or more. For cooler climates, less fertile soils, or small-growing vines, 80 square feet or even less may suffice. For square planting and vase-formed vines, 9 by 9 feet or 10 by 10 feet are appropriate distances, with avenues of 18 or 20 feet at convenient intervals. In the coolest areas a spacing of 8 by 8 feet may sometimes be satisfactory. For avenue planting of vase-formed, small-growing vines, 8 by 10 feet is convenient; under some conditions, 7 by 9 feet may be satisfactory. Trellised vines of raisin and table varieties are usually planted 8 by 12 feet—a good distance for most large-growing vines.

LAYING OUT THE VINEYARD

In large vineyards—40 acres or more—surveying instruments are convenient for dividing the area accurately into blocks of the desired size. The position of each row may be located with the surveyor's chain or with a special "row chain" made by melting buttons of solder on to a no. 11 smooth galvanized wire at the distance the rows are to be spaced.[6] The individual vines in each row are nearly always located by using a planting line, made as described for the row chain except that the solder buttons are spaced according to the spacing distance of the vines in the row. The positions of the vines are marked by driving temporary planting pegs, $1 \times 1 \times 12$ inches, or permanent stakes at each button on the planting line. Regularity in lining up the vines and stakes and in planting the vines is necessary for the economical handling of the vineyard later.

PLANTING THE VINEYARD

The rootings, or grafted vines, are pruned before planting, the tops being cut back to a single good spur of one or two buds. For convenience in planting, the roots are shortened to 3 or 4 inches. All roots on the top 8 inches of the vine are removed entirely.

The vines must be carefully protected from drying out in all handling operations from their removal from the nursery to their planting in the vineyard. When stored they should be heeled-in (partially buried) in moist sand or soil in a cool place. While being moved from the storage place to the vineyard they must be well covered with moist sacks or canvas or, better still, hauled in tubs containing 2 or 3 inches of water. The planters carry the vines in planting-cans. (Those made from 5-gallon paint buckets or 5-gallon oil cans are very satisfactory.) Two or 3 inches of water in the planting cans will keep the roots wet.

[6] A soldering flux of hydrochloric acid and zinc chloride may be used to make the solder stick to the wire.

The holes for the vines should all be dug on the same side of the planting pegs or stakes. In digging the hole, one should not remove the peg, but should dig so that the side or corner of the hole at the peg slopes away from the peg 1 or 2 inches distant at the bottom. The hole should be slightly deeper than the vine is long. Then to plant the vine drop it into the hole with the top close to the peg; fill the hole to one half or two thirds of its depth with loose, moist top soil; raise the vine to the proper height and *pack the soil firmly* about the roots with the feet; fill the hole almost

Fig. 2.—A simple two-wire trellis in a young Thompson Seedless vineyard.

completely and again pack the soil firmly; finish filling the hole and cover the top of the vine, leaving the top soil well pulverized but loose. When the work is completed, the top of the vine should be exactly at the side of the peg, and the roots 1 or 2 inches away from the peg. All vines must be slanting in the *same direction* so that the permanent stakes may be placed close to each vine on the side to which the top slants without danger of breaking the vine. Rootings of the fruiting varieties should be planted so that the two buds left after pruning are just above the general level of the ground. Bench-grafted vines are planted with the union about an inch above ground level. The tops of all are covered to a depth of ½ to 2 inches with a mound of loose soil to prevent drying before growth starts.

SUPPORTS FOR THE VINES

All vines should have some support, temporary or permanent. For vase-formed vines, stakes 4 to 6 feet long are sufficient. In six to ten years these may be removed, as the vines should then be self-supporting. For simple

two-wire trellises, a 6-foot stake at each vine is sufficient, with two no. 11 or no. 12 smooth, galvanized fencing wires stretched along the row at 34 and 46 inches from the ground (fig. 2). These supports are best put in place before the vineyard is planted, but for economy this work may be delayed until the winter immediately after the planting; it should not be delayed longer.

Often, for large-growing table-grape varieties, a "wide-top" trellis (fig. 3) is constructed by tying a crossarm (2 × 2 inches × 3 feet) to the

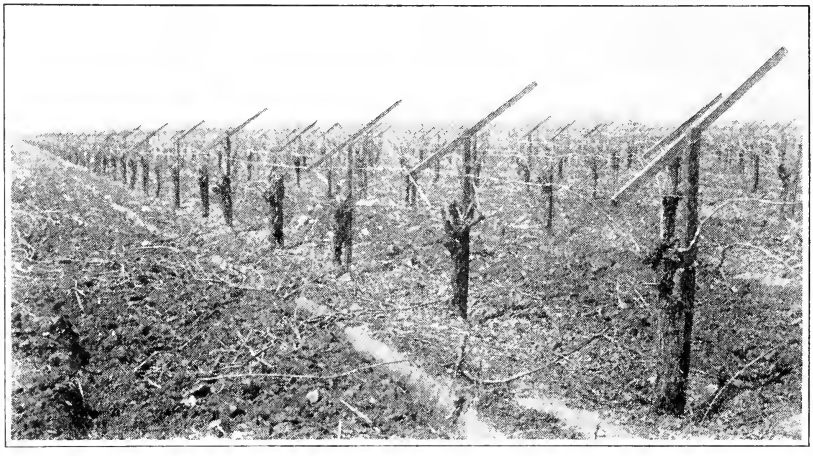


Fig. 3.—A sloping, wide-top trellis.

top of each alternate stake and bracing the lower end to hold the crossarm at an angle of about 30° from the horizontal. The lower end is about 15 inches long; the upper end about 21 inches. One wire is usually fastened to the stakes just below the crossarms, and three wires are used on the crossarms. This type of trellis has certain advantages: (1) More fruiting wood may be retained at pruning. (2) Since the clusters are better distributed, better exposure to light and air is obtained. (3) Thinning, girdling (on Thompson Seedless), and harvesting are facilitated.

PRUNING[7]

The following special terms are defined as they are commonly used in vineyard practice: *Pruning* consists in removing canes, shoots, leaves, and other vegetative parts of the vine. *Thinning* is the removal of flower clusters, immature clusters, or parts of clusters (the removal of ripe fruit is harvesting). *Training* consists principally in attaching the vine

[7] The principles and practice of pruning vines are more fully discussed in: Winkler, A. J. Pruning vinifera grapevines. California Agr. Ext. Cir. 89:1–67. 1934.

and its growth to various forms of support. *Shoots* are the current season's succulent top growth. *Canes* are matured shoots. The *trunk* is the undivided body of the vine. *Arms* are primary, secondary, or tertiary branches. A *spur* is the basal portion of a cane from one to four buds or nodes in length. A *fruit spur* is one that is intended primarily to bear fruit. *Renewal spurs* are intended to produce canes that may be used the next season for spurs or fruit canes; and *replacement spurs* are used to shorten or replace arms or branches; renewal and replacement spurs may or may not bear fruit. A *fruit cane* is the basal section of a cane, eight to fifteen buds long, used to produce the crop and always removed at the following pruning. *Water sprouts* are any shoots that arise on parts of the vine older than one year. *Suckers* are water sprouts that arise below ground; the term is also frequently applied to water sprouts from the trunk and main branches.

FUNCTIONS OF PRUNING

The main and only essential functions of pruning are to give the vine a definite form and to keep it within the limits necessary for economical culture—for performing such operations as tillage, irrigation, disease and pest control, and harvesting. Other purposes, such as the prevention of overbearing, the promotion of set of berries, and the production of good-quality fruit may be attained by other means. Unfortunately these other means are sometimes inadvisable because of their difficulty or high cost.

INFLUENCE OF PRUNING

Pruning, with reference to the removal of living parts, has two effects: it concentrates the activities of the vine into the parts left; and it diminishes the total capacity of the vine for growth and fruit bearing. Correct pruning consists in utilizing the first effect to the extent required while avoiding the second effect as much as possible.

Other things being equal, a heavily pruned vine will produce fewer leaves than one lightly pruned. It will also produce its maximum number of leaves and maximum area of foliage surface later in the season, so that the total annual work of photosynthesis will be less. In consequence, smaller quantities of carbohydrates—sugar, starch, and the like—will be formed; and the amount available for the nourishment of root, stem, branch, flower, and fruit will be less. This effect, unless the crop is controlled by thinning, is usually masked by the fact that the lightly pruned vine produces a very large crop; and, as the crop weakens the vine to an extent comparable with the effect of pruning, the actual production of wood, foliage, and fruit by the lightly pruned vine, over a series of years,

may be no more or even less than that of the heavily pruned. If the crop is restricted by appropriate thinning, however, the lightly pruned vine will usually produce more crop and make more growth than the heavily pruned.

SYSTEMS OF PRUNING

The various styles of pruning used in commercial vineyards in California may be grouped into three main classes or systems; namely, head, cane, and cordon.

Head Pruning.—In the head system the vine is given the form of a small, upright shrub. The mature vine consists of a vertical stem or trunk, 1 to 3 feet high, bearing at its summit a ring of arms or short branches ascending in the form of a vase or a hollow, inverted cone. At the ends of these arms, at each winter pruning, are left spurs to produce the shoots that will bear the next crop and furnish canes for the next year's spurs. Thus, this system consists of head training and spur pruning. The point or region where the trunk divides into or bears the arms is called the head (fig. 4).

The advantages of head pruning are simplicity of form, ease of training, and cheapness. The headed vine is the easiest type to establish, largely because the trunk is relatively short and upright. The cost of support is relatively low. During the developmental period, stakes are necessary; but after five to ten years, the trunks are rigid enough to be self-supporting. Cross-cultivation is possible, a feature that may be advantageous when the control of noxious weeds is a problem.

The disadvantages of head pruning lie principally in the depressing effect of severe pruning on the growth and productivity of the vines and in the massing of the fruit within a small area. When crop is controlled entirely by pruning, as with most head-pruned varieties, the pruning must be severe in order to prevent overbearing.

Head pruning suits most varieties that bear well on short spurs when fine appearance of the fruit is not of paramount importance. It is used for most wine grapes, for the raisin Muscat, and for a few table varieties, notably the Tokay.

Cane Pruning.—In cane pruning, the vine is given a trunk of form similar to that in head pruning. The head of the vine differs in being fan-shaped in the plane of the trellis. Only two arms on each side of the head are usually needed. At each annual pruning after the vines are mature, fruit canes eight to fifteen buds (2 to 5 feet) long are retained for producing the crop (fig. 5). The old fruit canes are removed each year. The production of canes for use the following year is left largely to the

renewal spurs, usually two buds long and located near the base of each fruit cane.

Cane pruning is necessary for varieties, such as the Thompson Seedless, that have mostly unfruitful buds near the base of the canes. It also insures full crops with varieties that produce very small clusters, such

Fig. 4.—A mature head-pruned vine.

as the Rieslings. Combined with appropriate thinning to regulate crop, it offers other advantages: the fruit may be distributed over a large area; the tendency of certain varieties, like the Muscat of Alexandria and the Dattier, to produce shot berries and straggly clusters may be reduced; and, since there will be more clusters than are needed for a crop, the grower may eliminate the least desirable ones by thinning, and thus improve the average quality of the fruit.

The disadvantages of cane pruning are twofold: the tendency of most

varieties to overbear, with consequent production of poor fruit, unless adequate thinning methods are employed; and the high costs of pruning and of supports—a trellis is usually necessary. For raisin and wine grapes the simple two-wire trellis is sufficient, but for fine table grapes the wide-topped trellis is better.

Cordon Pruning.—The vines of cordon pruning have no definite head. The trunk, which is much elongated either vertically or horizontally, bears arms at intervals of 8 to 12 inches over the greater part of its

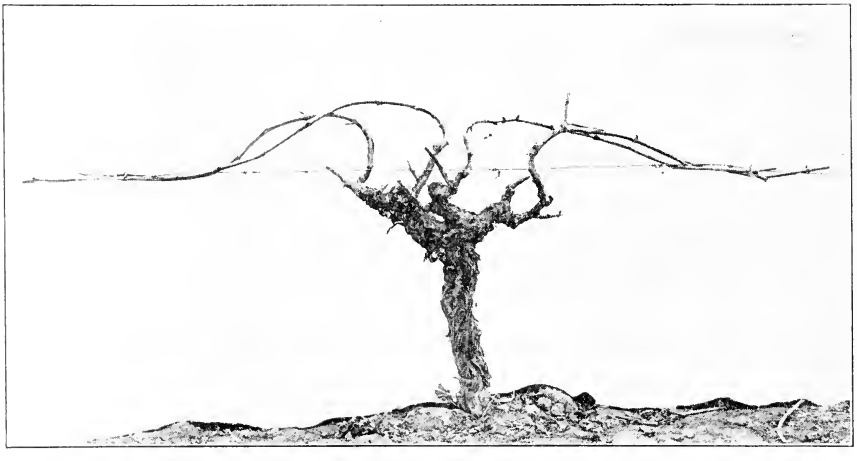


Fig. 5.—A mature cane-pruned vine on a two-wire trellis. (From Cir. 277.)

length. In California the horizontal bilateral form is the only one recommended. The trunk rises vertically to a point about 8 inches below the lower wire of a trellis. At this point it divides into two equal branches, which rise to the wire in quarter circles and extend in opposite directions along the lower wire to points halfway to the adjacent vines on either side. The bends should be smooth and regular; the horizontal portions straight. No shoots should be permitted on the bends. The bearing units are spurs on small arms located at regular intervals on the horizontal part of the branches. They should, wherever possible, be on the upper side of the branches or at least extending in an upward direction if they originate elsewhere (fig. 6).

The fruit on horizontal cordon-pruned vines is well distributed, with the clusters all hanging at about the same distance from the ground—conditions favorable to uniform development and maturation of the fruit. Some varieties that require long spurs with head training bear fair crops on spurs of normal length when pruned by the cordon system.

The greater length of the trunk of the vines makes the cordon the most laborious and most expensive system to establish. Not only is more work required, but the labor employed must be more skilled, and a trellis or some other permanent support is essential.

The use of this system in California is practically limited to table-grape varieties, particularly Malaga, Red Malaga, Ribier, and Emperor.

Fig. 6.—A mature horizontal, bilateral, cordon-pruned vine. (From Ext. Cir. 89.)

PRUNING OF BEARING VINES

Head Pruning of Bearing Vines.—Sufficient spurs should be left to yield a full crop of good quality while still maintaining the form and vigor of the vine. To determine easily the number and length of spurs to leave on a mature vine, one may roughly count those left the previous year, observing the size of the canes and the number of clusters produced. A vine that produced a good crop and has canes of normal size should be pruned to about the same number of spurs of similar length (as measured by the number of buds) as the year before. If the canes are abnormally large for the variety, indicating that they were very vigorous the previous summer, more spurs, or longer spurs, or both, should usually be left in order to utilize this capacity in the production of fruit. If, on the other hand, the canes appear weak—that is, small for the variety—fewer buds should be left. To reduce the number of buds, one may reduce the number of spurs retained or may cut the spurs shorter. Spurs retained from

large or vigorous canes should carry more buds than those retained from small or weak canes.

The spurs should be so placed that the form of the vine is maintained or improved and the fruit uniformly distributed. Whenever possible, canes from near the base of last year's spurs should be used for the new spurs. The arms elongate from year to year. When an arm becomes too long it is shortened to a replacement spur made from a water sprout, or other cane.

Cane Pruning of Bearing Vines.—The renewal spurs left the previous season should have produced two good canes apiece. On an ideally shaped vine the uppermost cane on the spur would be used for the fruit cane, and the lower one cut back to two buds to form the new renewal spur. Wherever feasible, this practice should be followed. If, however, enough good canes cannot be obtained from the old renewal spurs, then canes arising near the base of the old fruit cane, or even water sprouts, may be used for the new fruit canes or renewal spurs.

The number of fruit canes needed varies from one to six according to the size and total growth of the vine. The length of these canes depends upon their individual size: large ones may be left to a maximum length of fifteen buds; small ones should have proportionally fewer buds. If the crop is to be regulated by thinning, as with all table varieties when cane-pruned, a standard number and length of fruit canes may be adopted, and the crop on each regulated according to its vigor.

The renewal spurs should usually be about 1½ times as numerous as the fruit canes and should be so placed as to maintain or improve the form of the vine.

Cordon Pruning of Bearing Vines.—Since the annual pruning of the cordon vine consists in the leaving of spurs, it resembles head pruning: in choosing the wood and estimating the number of buds to be left, the pruner proceeds in exactly the same manner. To maintain the capacity of the individual arms at the same level, the length of the spurs left must be regulated in accordance with the size of the canes from which they are made. Since the arms of the horizontal cordon are upright, the most vigorous growth is usually at the ends of the spurs, and the arms may tend to become too long very rapidly unless the wood for the spurs is very carefully selected and replacement spurs are judiciously used.

Pruning Vines on Arbors.—The pruning of vines on an arbor or pergola does not differ essentially from that of other vines. The form given to the vine depends on the space to be covered and the fruiting habits of the variety. Thompson Seedless and other varieties that have mostly sterile buds on the basal portion of the canes must be cane pruned.

Such vines should be headed at or near the top of the arbor. The pruning is as described for the cane system (fig. 7).

Vines of other varieties should be trained and pruned as multiple, horizontal cordons; that is, each branch on the top, or side, of the arbor should be treated as a cordon. After the vine has been made to cover the required space, through the gradual increase and elongation of branches by the use of canes, spur-pruning is preferable.

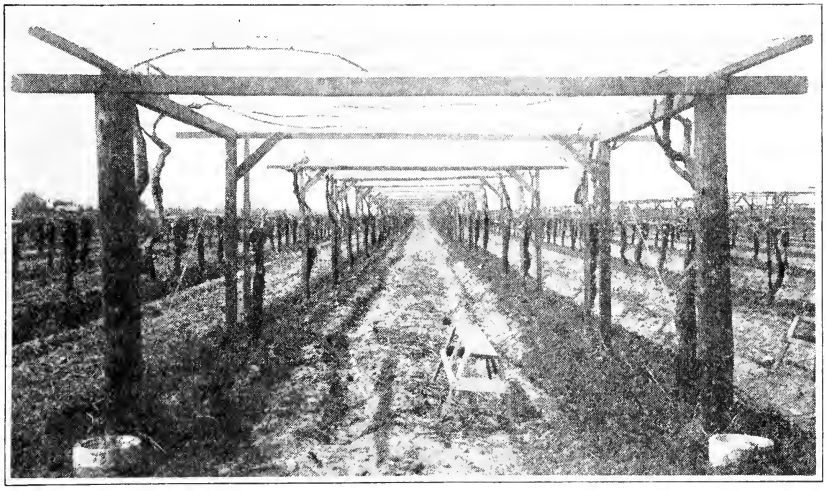


Fig. 7.—Ohanez vines on an arbor, cane-pruned.

Summer Pruning.—Suckering, crown suckering, pinching, topping, and the removal of leaves are the operations constituting summer pruning. Suckering—the removal of water sprouts from the trunk and from below ground—should be done carefully and thoroughly in every young vineyard and at least once each year in an old vineyard. As a rule no water sprouts should be permitted on the undivided portion of the trunk of mature vines either above or below ground.

Crown suckering—the removal of water sprouts from the branches and arms—should be employed with care. Sometimes one may open the head of the vine in order to improve the quality of the fruit or to concentrate growth in parts where it is wanted. The removal of unfruitful shoots in all cases, on the theory that they are useless, is a mistake. The foliage that they produce nourishes the vine and makes it more capable of bearing. Also, some of them may be needed for use as replacing spurs. The constant and thorough removal of all water sprouts from the large branches and arms exposes them to the sun's direct rays and is the cause of "bald-headed" vines.

Pinching—the removal of the growing tip of a shoot with thumb and finger—is often useful in arresting the elongation of very vigorous shoots, to lessen wind damage, and is an aid in developing young vines.[8]

Topping consists in removing 1 to 2 feet of the end of a growing shoot, usually in June or July. In very windy districts the practice may be advisable, for it is better to cut off part of the shoot and save the remainder than to have the wind break off the entire shoot. Since leaves are removed, however, the practice weakens the vine, and constant severe topping may greatly depress the vigor and crop of even the strongest vines.

Judicious removal of leaves sometimes facilitates the coloring of certain varieties by opening the vines to permit better exposure of the clusters. If the leaves are left on until the fruit has attained the minimum sugar content desired, little or no harm will be done to either the vine or the fruit. Should leaves be removed before the fruit reaches the minimum sugar content for harvesting, its maturation as well as the development of color may be retarded. To improve the coloring of the fruit, only the leaves in the head of staked vines and those on the lower part of the north or east side of trellised vines should be removed.

DEVELOPING YOUNG VINES

The development of young vines in commercial vineyards follows a rather definite procedure, which makes use of pruning and disbudding to direct the growth and of tying to stakes or trellises to maintain the vine in the desired position. Usually four years are required to complete the training.

CARE DURING THE FIRST SUMMER

Throughout the first year, the main object is to develop a good root system. Cultivation and irrigation should be conducted with this in mind. The frequency of irrigation and the quantity of water applied will depend upon climatic and soil conditions. At least one irrigation in late spring or early summer is always helpful in promoting growth of the comparatively shallow roots of the young vines. In hot climates two, three, or more applications may be needed. Late irrigation in the autumn should be avoided because it may render the vines liable to injury from early winter frosts. Usually no pruning or training should be done in the first growing season, except in very hot regions, where often the vines may be trained during the first summer as described for the second.

[8] See pages 23–28.

At the end of the first growing season, the vines should possess a well-established root system and a well-matured top growth. The whole of this top growth, except the strongest cane, should be pruned off sometime during the winter. The reserved cane is then usually shortened to two or three well-formed buds.

TRAINING THE SECOND YEAR

The object of the second year's work is to develop a single strong, well-matured cane with or without lateral branches from which to form the permanent trunk. This is accomplished by "disbudding" in such a way as to direct the whole growing capacity of the vine into a single cane. Soon after the buds start and before any have developed into shoots of more than 4 inches, they should all be rubbed off except one. The shoot reserved should be the strongest that is well placed for growing vertically near the stake. As this shoot grows, it should be tied loosely to the stake to maintain it straight and vertical. It is first tied when 8 to 12 inches long and is retied once or twice more until it reaches the height at which the trunk divides, all other shoots being removed from the old wood as they begin to develop. The laterals that may grow on the reserved shoot should not be removed. If any of these below the middle of the shoot show signs of developing as rapidly as the main shoot, they should be pinched back. The main shoot should be pinched when it has grown 8 or 10 inches above the point at which the trunk will divide to form the branches or arms of the vine (fig. 8).

Up to this time the vines under all pruning systems are handled exactly alike. Beyond this point the training of the cordon differs from that of the head and cane systems, which remain alike for another year.

With vines to be head- or cane-pruned, all laterals on the upper half of the shoot are usually allowed to grow without pinching.

To form the bilateral horizontal cordon, two laterals (or the main shoot and one lateral) are selected to form the two branches of the vine. All other laterals are pinched back or, if vigorous, are removed entirely. The point where they divide should be 6 to 10 inches below the wire of the trellis that will support the cordon. When the laterals have made 18 to 24 inches' growth, one of them is tied in each direction on the trellis. As they continue to grow, they are kept straight by being tied loosely to the wire. No ties are placed on the portion of the shoot that is elongating—a few inches to a foot or more from the tip, according to the rate of growth. The laterals are pinched after they have grown about 2 feet beyond the halfway point to the next vine.

At the end of the second summer, vines that are to be head- or cane-

pruned should have developed a strong cane, which will form the permanent trunk, and several laterals on the upper half of the trunk cane. The trunk cane is cut off at the first node above the level where the head is desired. The cut should be made through the node in a way that destroys the bud but leaves the enlargement; this technique facilitates tying. All

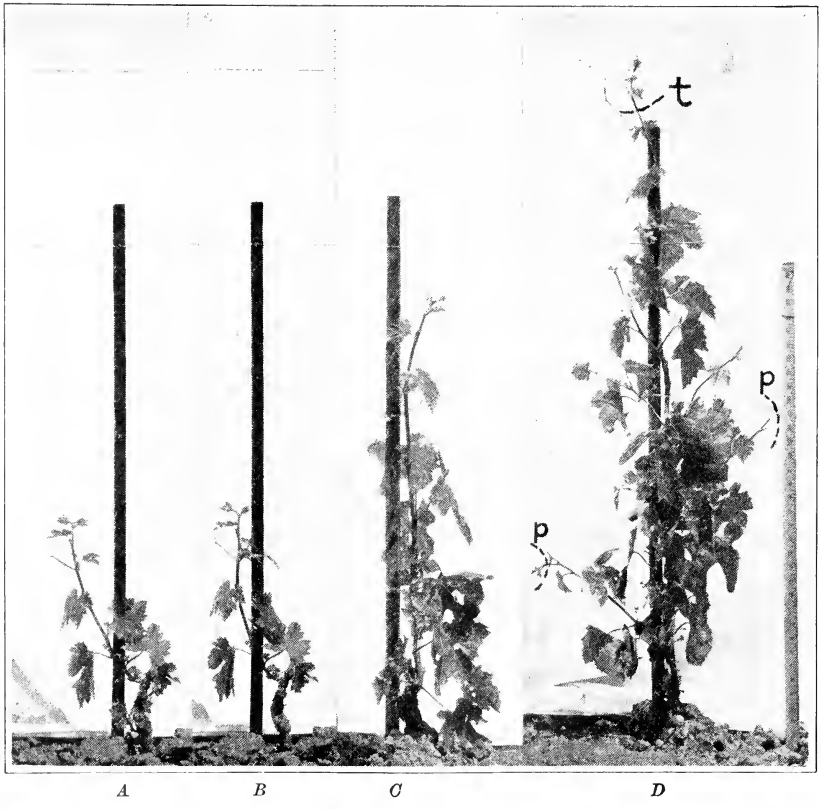


Fig. 8.—Training the second summer: *A*, Before the second disbudding; *B*, *C*, and *D*, manner of tying the reserved shoot to the support during the second summer. Strong-growing, low laterals are pinched at *p* to check their growth. When the main shoot has grown 8 to 12 inches above the height at which the trunk will divide, it is pinched, as indicated at *t*. (From Ext. Cir. 89.)

small laterals and all laterals below the middle are removed. On exceptionally large vines, one to three laterals over $\frac{5}{16}$ inch thick on the upper half of the cane may be cut back to one or two buds, according to their strength. These will act as fruiting spurs and will help to develop the head rapidly. A single fruit cane may be left on very vigorous cane-pruned vines.

Vines on which the trunk cane is less than $\frac{3}{10}$ inch thick at the desired

height of the head should usually be cut back to two buds as at the first winter pruning.

A single hitch, two half hitches, or a clove hitch is made around the trunk cane just below the enlargement of the node that was cut through, and the string is tied around the stake as tightly as possible with a firm square knot. A loose tie is then placed around the stake and the trunk cane at about the middle; it must not pass around the cane between the

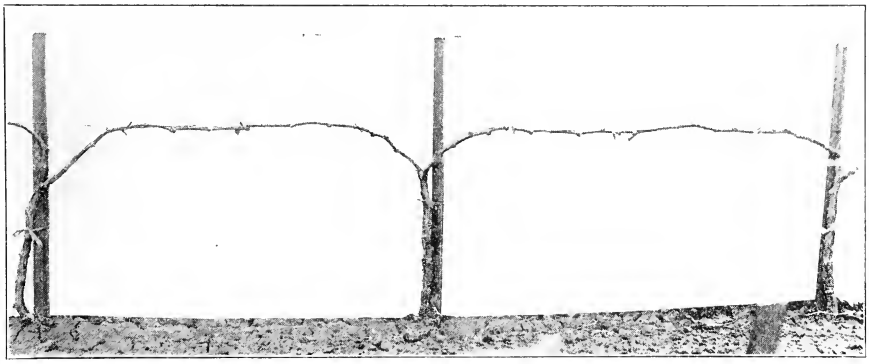


Fig. 9.—The completed trunk and branches of a horizontal, bilateral, cordon vine tied to the wire—the second (or third) winter. (From Cir. 277.)

cane and the stake, or the vine may be girdled. (For this manner of tying, see figure 10.)

Cordon vines at the end of the second summer should have the trunk and the laterals for the branches fairly well formed. At the second winter pruning the branches should be cut back to a place where they are at least ½ inch thick. If they have grown sufficiently, they may be cut at a point halfway to the adjoining vines (fig. 9). If the canes are not large enough to reach at least 12 inches along the wire beyond the bend, they should be cut back to the point where the trunk was divided, and more vigorous canes grown the next year. All laterals on the trunk below the point of branching are removed entirely; and unless the vines are extremely vigorous, no spurs are left on the branches.

CARE DURING THE THIRD YEAR

The vines in the third summer will bear crops of varying amounts according to their size. During this time, however, the main object is to develop the permanent branches. All shoots that start on the lower half of the trunks of head- and cane-pruned vines should be removed before they make much growth (fig. 10). Shoots starting on the upper half of the vine may be allowed to grow without interference except that the most

Fig. 10.—Training the third summer: The first disbudding in head or cane pruning. (From Cir. 277.)

vigorous may be tied or pinched if there is danger that the wind may break them off.

At the third winter pruning of head-pruned vines, enough canes should be reserved and cut back to spurs to bear whatever crop the vine can carry without injury to its vigor or to the proper maturing of the grapes. This will usually be from three to six canes, according to the vigor of the vine. Each spur should be cut back to two, three, or four

buds according to the size of the cane from which it is retained. These spurs should be as near the top of the vine as is practicable.

On cane-pruned vines one or two fruit canes, each 2 to 4 feet long, according to their size, should be left and tied to the supporting trellis. To supply canes for the following year one should leave from two to four renewal spurs, all as nearly as possible at the desired height of the permanent arms into which they will develop.

Cordon vines require much more care. While the buds are starting in the spring, the vineyard should be gone over several times, and the shoots starting on the underside of the branches rubbed off. This practice will remove about half the shoots and leave the other half, spaced 6 to 10 inches apart on the upper side. At the same time all shoots starting on the trunk or on the bends of the branches should be removed.

As the shoots that are retained grow at uneven rates, some will soon be much longer than the others. These long shoots are usually either near the bends or at the ends of the branches. They should be pinched as soon as possible without injuring the blossom clusters, which are usually located at the third and fourth nodes. This pinching will check their growth and allow the weaker shoots to catch up with them.

On vines that do not extend the full length, a shoot should be allowed to grow from near the end of the incomplete branch to complete it. This shoot should be tied to the wire so as to make the extension of the branch as straight as possible. For this purpose a shoot from the underside of the branch is usually best.

As soon as the shoots are sufficiently long, several from near the end of each branch should be tied to the upper wire. Otherwise the weight of all the shoots, together with that of the fruit, will turn the branch completely over, leaving the upper side bare and the shoots all pointing downward. If this trouble is not soon corrected, the vine can never be made into a good cordon.

Overbearing must be prevented. Usually, if the disbudding has been done as described, enough potential fruit will have been removed. If, however, the young vines seem to bear more fruit than they can develop to good quality, some of it should be removed by thinning.

At the third winter pruning, spurs one to three buds long are retained at regular intervals, 8 to 12 inches, spaced along the upper side of the horizontal portions of the branches. All other canes are removed. All old ties on the trunk and branches must be cut, and the vine retied to make the horizontal portions of the branches as straight as possible.

CARE DURING THE FOURTH YEAR

In the fourth and subsequent years the aim is to perfect the structure of the vine so that all essential vineyard operations will be facilitated and the vines will bear their maximum crops of best-quality fruit. Head-pruned vines will be developed gradually into symmetrical vase forms. The heads of cane-pruned vines will be developed fan-shaped in the plane of the trellis, and thus interfere as little as possible with cultivation. The arms of bilateral cordon-pruned vines should be uniformly spaced over the horizontal portions of the branches; they should be maintained upright by tying green shoots to the top wire, particularly until the branches are large enough to resist the twisting effects of the growth and crop that might be heavy on one side of the trellis; they should be kept at the same height and uniformly vigorous by careful pruning and judicious pinching.

During the summer all water sprouts should be removed from the trunk below the lowermost arm on head- and cane-pruned vines. All water sprouts except those needed in developing new arms are removed from the branches and trunks of cordon-pruned vines.

Vines that grow slowly may lag behind this program, whereas very vigorous vines in hot regions may be ahead of schedule. In either case the adjustment is usually made at the first or second winter pruning. Weak young vines may be cut back to two or three buds the second winter, a practice that delays the subsequent operations by one year. With very vigorous vines, the four years' work of developing may be completed in three years.

THINNING

Three distinct types of fruit thinning are used on grapes—*flower-cluster thinning, cluster thinning,* and *berry thinning.* All types of thinning owe their effectiveness to a reduction in the number of flowers or fruits and to the better nourishment of those that are left. Since each, however, has a distinct purpose and is applicable to a different type of grape, the method chosen depends on the type of fruit produced by a variety or a vineyard.

FLOWER-CLUSTER THINNING

The clusters of rudimentary flowers of the grape appear with the leaves in early spring. The individual flower parts continue to develop until blooming occurs (from 6 to 8 weeks). To remove some of the flower clusters soon after they emerge, without removing any leaves, improves the nutrition of those remaining. As a result, a better set of normal berries

may be secured. Flower-cluster thinning is therefore useful on varieties that have loose or straggly clusters, or which set many shot berries with the usual pruning, such as the Muscat of Alexandria and Dattier. For best results the vines should be long-pruned (long spurs or fruit canes)

Fig. 11.—A single cane of a Muscat vine, showing the proper stage of development for flower-cluster thinning. (From Bul. 519.)

and thinned as soon as possible after the flower clusters appear (fig. 11). This type of thinning should never be used on varieties that produce compact clusters, like the Tokay.

CLUSTER THINNING

Cluster thinning consists in the removal of entire clusters soon after the berries have set, after blooming. The most widely useful of the three types, it is the easiest and best means of reducing the crop on overloaded vines of wine- and raisin-grape varieties to insure that the remainder will develop and mature properly. By leaving enough fruiting wood (spurs or canes) at pruning time to produce a good crop in poor years and then reducing the overload in good years by cluster thinning, one may secure large, regular crops almost every year.

Cluster thinning, since it is not done until after blooming, does not influence the number of berries that set; and since entire clusters are removed it does not appreciably change the character of those retained. By improving the nutrition of the fruit that is left, it does enhance the size and coloring of the berries and hastens maturity. The average quality of table grapes may be further improved by retaining only the best clusters. At thinning time the clusters of table varieties should be disentangled from each other or from shoots around which they have formed. This will avoid damage to many fine clusters during harvest.

BERRY THINNING

As used in California, berry thinning consists in removing parts of the cluster, usually by cutting off the end of the main stem and several branches of the cluster or by cutting off enough of the main stem to leave only the desired number of berries. This method can improve quality only when an overabundance of berries makes the clusters too compact or when overlarge cluster parts interfere with proper coloring and maturation. In the improvement of quality, therefore, its usefulness is limited to varieties that set very compact or very large clusters. Berry thinning usually changes the character of the clusters materially (fig. 14); it always reduces their size and sometimes alters their shape. The thinning should be done as soon as possible after the drop of berry forms (flower receptacles) that normally follows blooming—that is, as soon as the berries have set.

GIRDLING

This operation, also called "ringing," consists in removing a *complete* ring of bark ⅛ to ¼ inch wide from the lower part of the trunk or from an arm or a cane below the fruit which it is intended to affect. As a result, the carbohydrates elaborated in the leaves will accumulate in the parts above the wound, including the clusters of blossoms or fruit, and will materially influence their development. The stage reached by the grapes at the time of girdling will largely determine the nature of the response.

GIRDLING TO IMPROVE THE SET OF BERRIES

Girdling done while the grapes are in bloom increases the number of seedless berries that set but does not cause any additional seeded berries to form. In no sense, therefore, is it a remedy for coulure (shedding of the flowers) except on seedless varieties. It improves the yield of the Black Corinth, which, without it, produces small, straggly clusters consisting mostly of tiny seedless berries and a few medium-sized seeded ones. Girdling at this time increases the number and size of seedless berries without influencing the number that have seeds (fig. 12). The Black Corinth is universally girdled during the blooming period. Trunk girdling is favored over girdling the arms or fruit canes because it affects the whole vine uniformly. The trunks of the Black Corinth tend, furthermore, to remain relatively small, and the trunk girdling is cheapest. Girdles 3/16 inch wide are adequate.

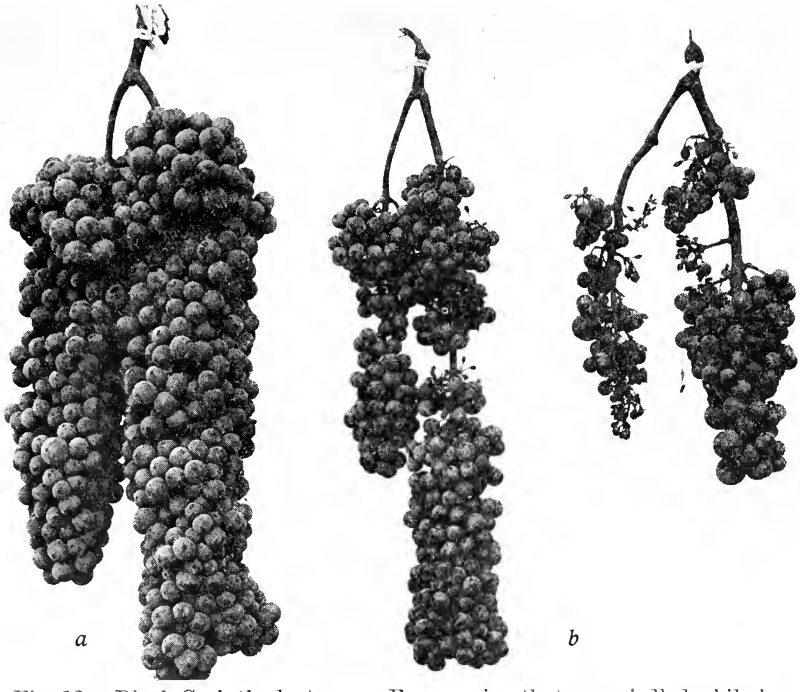


Fig. 12.—Black Corinth clusters: *a*, From a vine that was girdled while in bloom; *b*, from an ungirdled vine. (From Ext. Cir. 56.)

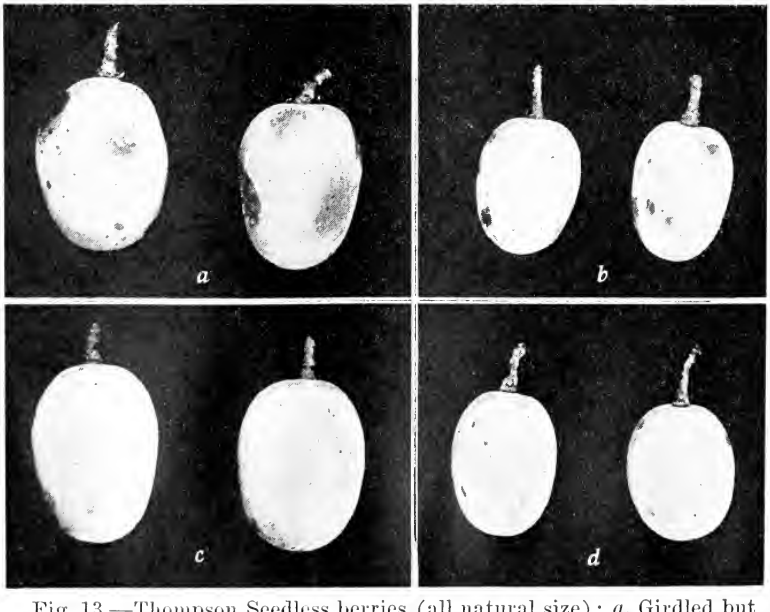


Fig. 13.—Thompson Seedless berries (all natural size): *a*, Girdled but not thinned; *b*, not girdled nor thinned; *c*, girdled and berry-thinned; *d*, berry-thinned but not girdled. (From Ext. Cir. 56.)

GIRDLING TO INCREASE BERRY SIZE

A complete girdle that is open and effective during the period of most rapid growth of the berries, which occurs within a few weeks after blooming, increases the size of seedless berries from 30 to 100 per cent, but of seeded berries usually less than 20 per cent. Figure 13 reproduces, in natural size, photographs of Thompson Seedless berries from girdled and ungirdled vines. If the operation is delayed until near the end of the normal drop of berry forms after blooming, the greatest increase in size of berries is obtained with little or no influence on the number.

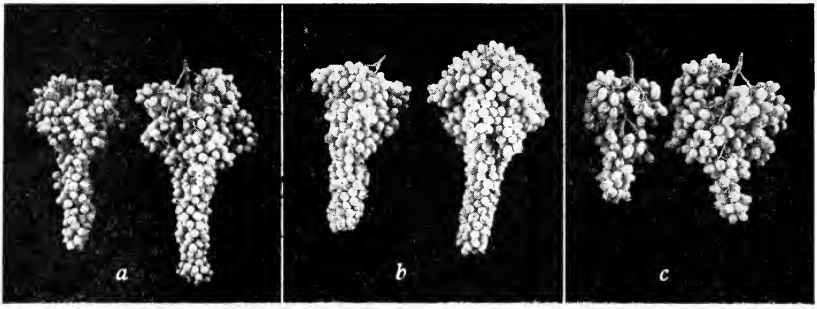


Fig.14.—Thompson Seedless clusters: *a*, From ungirdled vines, not thinned; *b*, unthinned clusters from girdled vines; *c*, berry-thinned clusters from girdled vines. (From Ext. Cir. 56.)

Thompson Seedless vines for producing table grapes are, therefore, girdled as soon as possible after the normal drop of the berry forms. If girdling comes too early—before the normal drop is complete—the clusters become too compact. If it is delayed more than 10 days or 2 weeks after blooming, the increase in berry size is less. The girdling may be done on either the trunks or the fruit canes with almost equally good results. The girdles are usually made $\frac{3}{16}$ or $\frac{1}{4}$ inch wide and heal over in 3 to 6 weeks.

Thinning is nearly always necessary when Thompson Seedless are girdled. The increase in total crop, without thinning, is roughly proportional to the increase in berry size; hence vines that are girdled but not thinned are nearly always overloaded, with consequent poor quality of fruit and weakening of the vines. Thompson Seedless clusters from ungirdled vines are normally well filled or compact. Since girdling increases the size of the berries but not the length of the stem parts, it increases the compactness of the clusters, even making them too compact (fig. 14).

The method of thinning will be determined in each instance by the character of the clusters. Cluster thinning (see page 30) should be used

to eliminate the least desirable clusters—those too compact, too small or too large, misshapen, or otherwise defective—leaving the required number of the best. Any of the remainder that are too compact must be berry-thinned (see page 31). The forked tip ends of all retained clusters should be cut off. In short, the thinning usually combines the cluster and berry methods.

Seeded varieties show little response to girdling. Although shot (seedless) berries of these varieties are improved in the same manner as are the berries of seedless varieties, the normal-seeded berries are increased in size only slightly. Nearly the same benefits may be obtained by thinning alone when a method suited to the variety is employed. Girdling to enlarge the berries of normal-seeded varieties is of doubtful economic value and is not recommended.

GIRDLING TO IMPROVE COLORING AND TO HASTEN RIPENING

To improve color and to hasten ripening, the girdles must be open and effective during the early part of the ripening period. Even then the desired result cannot always be obtained. The seedless varieties, Thompson Seedless in particular, are influenced in this respect but little, if at all. On the other hand, the coloring of Red Malaga and Ribier can often be hastened. The rate of ripening of most seeded varieties—Malaga, Muscat, Red Malaga, Ribier, and the like—may be slightly accelerated. The best results are obtained from vigorous vines having only a light crop. With a normal to heavy crop, often no response will be obtained.

Girdling to hasten ripening is of doubtful economic value except sometimes in very early districts where a few days' advance in maturity may mean a large difference in price—sufficient to compensate for the reduced crops, the added expense, and the risk of failure. As a rule, ripening and improvement in coloring are best obtained by thinning alone.

MAKING THE GIRDLE

For girdling the trunks various double-bladed knives are used, one of which is illustrated in figure 15. Work done with an ordinary single-bladed knife is usually less perfect and more expensive. Cane girdling is best performed with girdling pliers that have double blades on each side. With pliers such as those in figure 15 in position on a cane, one should cut through the bark by pressure on the handles, then release the pressure, rotate the pliers on the cane, and cut another section of the ring by squeezing the handles. This process continues until the cane is completely encircled. When the ring of bark has been cut completely around the cane, it is loosened by rotating the pliers, under slight pressure, around

the cane. The bark removed sticks in between the double blades and, with further use of the tool, passes on through between them. A spacing of $\frac{3}{16}$ inch between the double blades is recommended.

THE WEAKENING EFFECT OF GIRDLING

Because girdling stops the downward movement of organic food materials past the wound until after healing, the lower parts of the vine, particularly the roots, are undernourished while the wounds are open. The roots cannot explore new soil areas to get adequate amounts of water and

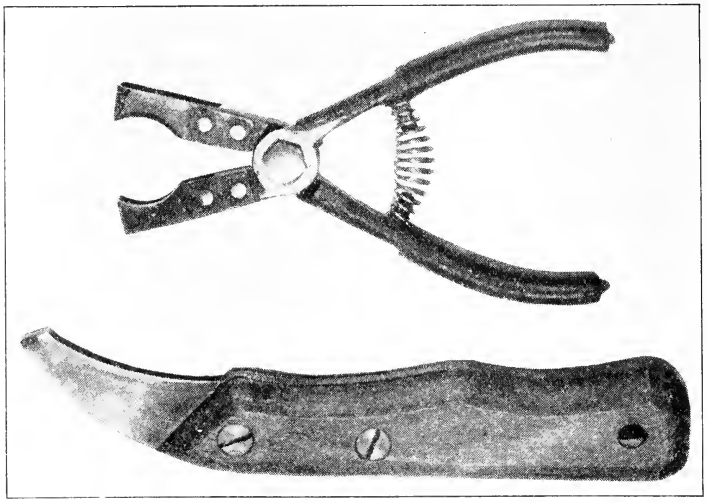


Fig. 15.—Girdling tools: Upper, cane-girdling pliers; lower, double-bladed trunk girdler.

other materials. The top growth is checked, and the leaves tend to become yellowish. The longer the wounds remain open, the more serious is the weakening effect. Trunk girdles that fail to bridge across during the growing season cause the death of the vines. Cane girdles that fail to heal are less serious. Girdles made during or soon after blooming and not more than $\frac{1}{4}$ inch wide will usually heal in 3 to 6 weeks, whereas those made later or wider or reopened to influence ripening will heal more slowly and have more of a weakening effect.

Good cultural care, particularly as regards irrigation, and also thinning to regulate the crop will render the girdle less weakening. The frequency of irrigation should be doubled while the wounds are open.

Overbearing of girdled vines must be avoided—with Black Corinth, by pruning; with Thompson Seedless and all other table varieties, by thinning so that the girdled vines carry not more than two thirds of the maximum crop they could mature if not girdled.

If properly thinned and well cared for, Thompson Seedless vines may be girdled year after year. One experimental lot of twenty mature vines in Stanislaus County has been girdled and thinned for eleven consecutive years with no apparent decrease in crop or growth.

In making the girdles only the bark—the tissue outside the cambium layer—should be removed. Cutting deeply into the wood is very serious because it destroys many of the most active conducting vessels in the outer layers of wood and thereby causes the vine to suffer from lack of water in the portions above the girdle.

CULTIVATION

The general purposes of cultivation are (1) to destroy weeds, and thereby remove their competition with the vines for water and soil nutrients; (2) to incorporate a covercrop or manure in the soil; (3) to prepare the land for irrigation; (4) to facilitate certain vineyard operations, such as leveling and smoothing the soil on which are placed the trays for drying raisins, or the planting of a covercrop; and (5) in some cases where the soil has been compacted, to aid in the penetration of rain which might otherwise be lost by surface runoff.

CULTIVATION IN UNIRRIGATED VINEYARDS

In unirrigated vineyards the only water available to the vines throughout most of the growing season is that left in the soil by the winter rains. California summers are almost entirely rainless, and but little rain falls in late spring after the vines have started to grow. Only rarely will the water that can be stored in that part of the soil penetrated by the vine roots suffice for maximum growth and maximum crops. The vines adjust themselves, however, to the limited supply; and if the amount available does not fluctuate greatly from year to year, they do not appear to suffer seriously from drought except that they remain smaller and bear lighter crops.

Any weeds allowed to grow after most of the winter rains have fallen will use part of the water, and thus reduce the amount available to the vines; hence, in unirrigated vineyards, the winter- and spring-growing weeds should be destroyed before they can rob the vines of appreciable amounts of soil moisture. The growth of summer weeds must be prevented. Since cultivation is the most practicable method of destroying or preventing weeds, unirrigated vineyards are cleaned up in early spring as soon as the soil is dry enough to work. The winter weeds, beneficial up to this time in reducing soil erosion and in acting as a fertilizing

covercrop, are incorporated into the soil. Cultivation is repeated only often enough to destroy or prevent further weed growth. It conserves soil moisture only by eliminating weeds and not in any sense by virtue of loosening or pulverizing the soil. Usually it may be discontinued as soon as the surface becomes too dry for seed germination. When, however, perennial noxious weeds, such as wild morning-glory, are present, the cultivation must be continued as late and as often as is necessary to check them. The manner of cultivation is relatively unimportant as long as it eliminates weeds, does not injure the vines, and discourages erosion. Rarely, if ever, should the maximum depth of cultivation exceed 6 inches.

CULTIVATION IN IRRIGATED VINEYARDS

The conservation of water is of less importance in irrigated than in unirrigated vineyards because additional moisture may be supplied to replace that removed by both vines and weeds. Irrigated vineyards are usually thoroughly cleaned up in the spring, and subsequent weeds are controlled during the period of rapid growth of the vines in order to eliminate the competition for soil nutrients. After early or midsummer, if enough irrigation water is available, weeds are controlled only to prevent undue interference with the various vineyard operations. In raisin vineyards where natural sun-drying is practiced, the soil between the rows is leveled and smoothed by cultivation and by dragging in order to prepare a place for the trays on which the grapes are dried. Cultivation is also needed to provide furrows or ridges for distributing the water.

IRRIGATION

The vineyards of the interior valleys of California are generally irrigated. A few in the Sacramento Valley and in certain high-water-table areas of the intermediate valley region and the San Joaquin Valley are not irrigated. In the north coast region irrigation of vineyards is rare. In the south coast region it is practiced wherever water is available, but owing to lack of water many vineyards in that area are irrigated inadequately or not at all. Even in the north coast region there are many nonirrigated vineyards that would be benefited if summer irrigations could be applied cheaply. In most of the vineyards on rolling lands, however, the cost would probably exceed the benefits.

The irrigation of vineyards does not differ greatly from that of deciduous fruit orchards.[9] The amount and the frequency of applications

[9] For a full discussion see: Veihmeyer, F. J., and A. H. Hendrickson. Essentials of irrigation and cultivation of orchards. California Agr. Ext. Cir. 50:1–24. Revised 1936.

are largely determined by texture and depth of the soil, climatic conditions, variety of grapes grown, and cultural methods.

During the late fall, winter, or early spring all the soil should be wet as deeply as the roots penetrate. Usually, after the vines start to grow, they are allowed almost to exhaust the available water in the zone containing most roots (usually 12 to 36 inches in depth); then the soil is wet once more to field capacity.[10] This practice may be continued until the grapes are nearly ripe. It is, however, good practice to time the application so that irrigation is avoided while the vines are in bloom and during the latter part of the ripening period. In the hottest districts one or more applications may be needed after harvesting. Weeds, particularly a late summer covercrop of grasses, increase the amount of water needed.

Vineyards may be irrigated by furrows, basins, or checks. The furrow system, which requires the least labor, is the most common. The basin system, although it distributes the water most uniformly, requires more labor and is usually impractical in a trellised vineyard. The check system (resembling that used for alfalfa) is applicable only to very sandy soils where large heads of water are available.

FERTILIZERS AND COVERCROPS

Of the three common fertilizer elements—nitrogen, phosphorus, and potassium—vines usually respond only to nitrogen. Economically favorable responses to phosphorus and potash are very rare in California.[11] Vines respond favorably to nitrogen only, however, when a lack of that element is limiting their growth and productivity—a condition that can be determined only by trial applications. Test plots of 100 vines or less to which nitrogen is applied, alongside of check plots on which none is used, are the best means of determining whether or not the vines will respond. For test purposes a rate of application of 40 to 80 pounds of nitrogen per acre (200 to 400 pounds of sulfate of amonia or its equivalent) is recommended. Manures and winery pomace, if available at low cost, are good fertilizers. Application of 10 to 20 tons of these materials per acre is recommended if tests show a need for nitrogen.

Covercrops are useful for several purposes. A winter-growing covercrop is an excellent aid in preventing soil erosion. It also utilizes the soluble nitrates that might otherwise be lost by leaching. When incor-

[10] The amount of water the soil will hold with perfect drainage.

[11] Certain European vineyards do respond markedly to phosphorus and potassium, but on the relatively virgin soils of California these materials have produced favorable results only in rare instances.

porated into the soil the covercrop decays, releases the nutrients for use again and brings other soil nutrients into solution. If the covercrop consists of leguminous plants, it may actually add nitrogen to the soil.

Late summer covercrops of grasses and other weeds are used advantageously in many table-grape vineyards. The soil is clean-cultivated until May or June; then a semipermanent irrigation system of furrows, basins, or checks is installed to serve the remainder of the season. Thereafter no cultivation is done. Among the weeds, grasses usually predominate. If the weed growth becomes so heavy that it may interfere with the ripening or harvesting of the grapes, the weeds are mowed or partially cut down with a heavy disk. This system is also common in many irrigated wine-grape vineyards and in alternate spaces between the rows in many raisin vineyards. Where it is used in the latter, each alternate avenue is kept clean, or cleaned up before harvest, to provide a suitable resting place for the trays on which the grapes are dried.

In vineyards where summer covercropping is practiced, the grapes usually have firmer texture, tougher skins, tougher and better-matured stems, a more brilliant color, and sometimes larger berries than in clean-cultivated vineyards. The vines, however, often make less growth; and when the practice is continued for years, the crops may decrease both in quantity and in quality. In such case the vineyard should be fertilized with a nitrogenous fertilizer or clean-cultivated for a year or two.

PROPAGATION

Grapevines are commercially propagated in California only by cuttings or grafts. In soils not infested with or immediately threatened by phylloxera, or heavily infested with nematode, rootings produced from cuttings of the desired fruiting variety are used. Phylloxera and nematode must be overcome by the use of resistant rootstocks, propagated by cuttings on which the desired fruiting variety is grafted either before or after rooting.

CUTTINGS

A cutting is a piece of the parent plant, which, under favorable conditions, will develop into a new plant. For grape cuttings, sections of canes (matured current season's growth) are always used.

Cuttings should be taken from healthy, vigorous vines of the proper variety—preferably mature vines that have grown well, borne moderate crops, remained free from disease, and not been injured by pinching, topping, or autumn frosts. Usually little can be gained by selecting parent vines on the basis of past performance; but still it is good prac-

tice to avoid off-types that are poorer than the average. These off-type vines may be of a different variety, or they may result from bud mutation. Most such variations are inferior, though occasionally one better than the original may be found and propagated.

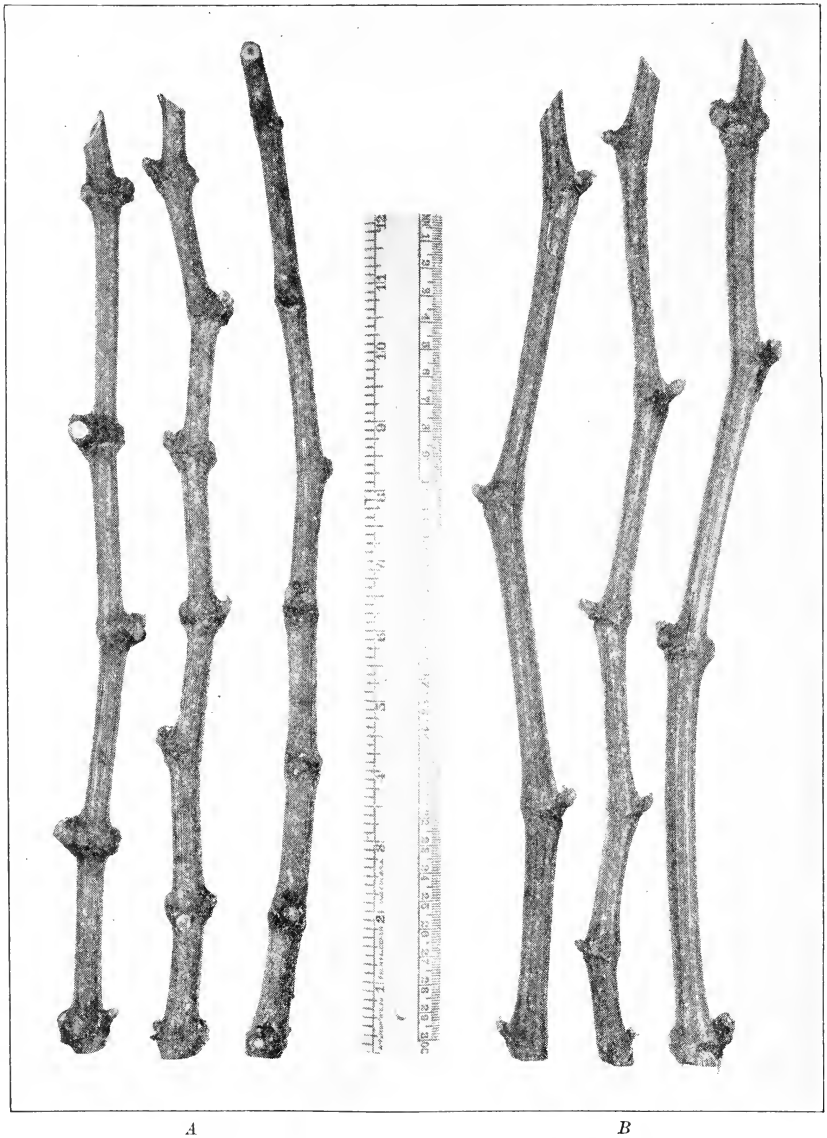
Grape cuttings should be made while the vines are dormant. They must be made promptly after the brush is pruned off the vines, since two or three warm, dry, windy days may dry the brush to such an extent that cuttings from it will not grow.

For canes from which to make cuttings, well-nourished, well-matured, current season's wood growth from any part of the vine is suitable. Cuttings from ⅓ to ½ inch in diameter and 14 to 18 inches long are commonly used. Seldom if ever should cuttings of the fruiting varieties be less than ¼ inch in diameter at the small end. A length of 14 inches is adequate. The resistant-rootstock varieties produce canes of smaller diameter than those of the fruiting kinds. Wood of normal size should be used. If the resistant cuttings are to be rooted, then planted into the vineyard, and finally budded, they should be longer than cuttings of the fruiting varieties—16 to 18 inches from the top bud to the base of the cutting.

The cut at the base of the cuttings is usually made straight across, just below a bud or node. The top cut is made at an angle of about 45° at a distance of ¾ to 1½ inches above the top bud (fig. 16). The angles of top and bottom cuts made in this manner will easily differentiate the top and bottom of the cutting in future handling operations. Also the sloping cut, removed ¾ inch or more from the top bud, avoids any cracking of the wood in the node, which might allow the top to dry out and thus injure the bud.

Cuttings should be planted in a well-drained soil as soon as possible after they are made. The nursery row is usually the best storage place. If, however, they cannot be planted immediately because of wet soil or other difficulties, they should be stored in a cool place, preferably in moist sand. For handling and storage, cuttings are conveniently tied into bundles of one or two hundred each.

The soil for the nursery should be fertile, preferably a sandy loam, with irrigation available. Even in the north coast region where vineyards are grown without irrigation, it is impracticable to grow a nursery without irrigation. The cuttings are planted usually to the depth of the second bud from the top of the cutting, and are completely covered with a ridge of loose soil. Though the procedure will vary with the scale of operations and the equipment available, any method of planting is suitable that places the cuttings at the proper depth in a straight row, with



A B

Fig. 16.—Grape cuttings: *A*, Muscat; *B*, Emperor.
(From Ext. Cir. 101.)

the soil around them firmly settled. If they are put in a trench, the soil must be firmly packed around the base of the cuttings by tramping as the trench is filled or by irrigation. If the cuttings are stuck in the cut made by a subsoiler, the soil must be settled around them by irrigation soon after the planting. In a fertile soil in a hot region, the cuttings may be

placed as close as 2 inches apart in the row with the rows 4 feet apart. In a less fertile soil or in a cooler region, 3- or 4-inch spacing in the row will produce larger and better rootings.

During the summer the nursery should be so cared for that roots and tops will grow well and yet be matured before autumn frost occurs. This aim is usually best accomplished by irrigating rather frequently in the early summer, less frequently in late summer, and not at all in the last six weeks or two months of expected growth. The ridges of soil over the tops should be left until the cuttings have rooted and made appreciable top growth. Then the ridges may be removed to discourage the formation of surface roots.

The rootings may be dug any time after the leaves fall. They should be sorted by size into at least two grades and bound into bundles of twenty-five or fifty each for convenience in handling. Until used they should be stored by heeling in moist sand or soil in a cool location. Rootings that have made less than 6 inches of well-matured top growth or that do not have at least one good root ⅛ inch in diameter from the basal node of the cutting should not be planted in the vineyard.

GRAFTING

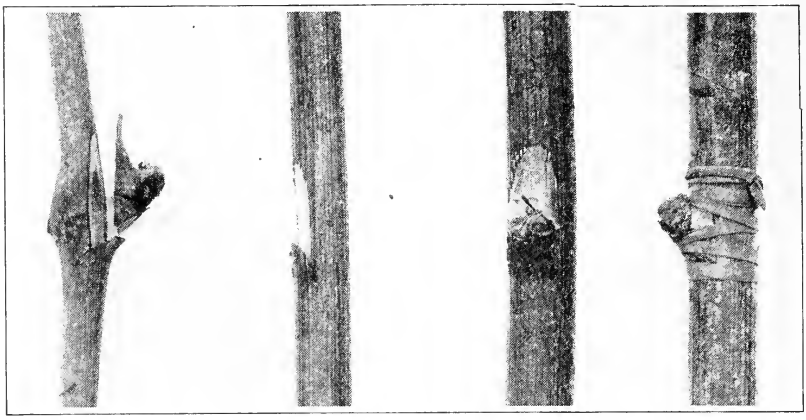
Only the methods of grafting applicable to vineyard use are given here.[12] Usually the actual budding or grafting is best done by a skilled workman. By following the directions given below, however, anyone can obtain good results.

Budding.—Stock rootings of resistant varieties that are to be budded or grafted should be made "sucker proof" by removing all eyes or buds from the below-ground portion before planting. They should be planted with 2 to 4 inches of their main body above the level of the ground so that the graft can be put in aboveground; scion roots can thus be avoided. Budding is done as early in the autumn as matured buds of the desired fruiting variety can be obtained—usually in August in the cooler regions, September in the warmer. The bark of the cane from which buds are taken must be light brown, since many buds from green canes or green parts of canes will not grow. As soon as the canes (bud sticks) are taken from the parent vine, the leaves are removed; and the bud sticks are kept fresh by wrapping them in moist burlap or by packing them in wet moss or in other suitable material.

A special form of chip bud (fig. 17) is most commonly employed. To remove a bud from the cane, two cuts are necessary. The first is made

[12] The methods of bench grafting used only by commercial nurserymen are described in: Jacob, H. E. Propagation of grapevines. California Agr. Ext. Cir. 101:1–36. 1936.

deep into the bud stick, beginning about ¼ inch below the bud and sloping downward at an angle of about 45°. The second cut is started about ⅝ or ¾ inch above the bud; and the knife, traveling in a nearly straight plane behind the bud, ends at the surface of the first cut, removing a wedge-shaped chip ⅛ to 3/16 inch thick at the lower end and a little less than 1 inch long (fig. 17, *A*). Some workmen reverse the order in which the cuts are made. The wood in the chip is not removed from the bud.



A *B* *C* *D*

Fig. 17.—Steps in budding vines: *A*, The bud removed from the bud stick; *B*, notch made in the stock to receive the bud; *C*, the bud in place; *D*, finished and tied, ready to be covered with soil.

A notch into which the bud will fit well is made in the stock just above ground level, preferably on the side of the vine from which most of the top growth arises. The work is facilitated by first removing the soil around the vine to a depth of 3 or 4 inches. The angle made by the two cut surfaces of the notch in the stock should be slightly more acute than the angle formed by the cut surfaces of the bud piece. This technique insures intimate contact between the lower end of the bud piece and the corresponding cut surface of the stock. The bud chip must be inserted into the notch in such a way that a good fit is obtained. It is then securely tied in place with budding rubber or raffia (fig. 17, *D*).

Immediately after being tied, the bud is covered with moist, well-pulverized soil; and this, in turn, is covered with 4 to 10 inches of well-pulverized soil. If the soil is fairly moist, a covering 4 inches deep may be adequate. If the soil is dry, 8 or 10 inches is better. In very dry soil it is well to cut off ¼ to ½ of the tops of the vines at the time of budding. The bud calluses in—that is, it grows fast to the stock—within 4 weeks. It usually remains dormant, however, until the following spring.

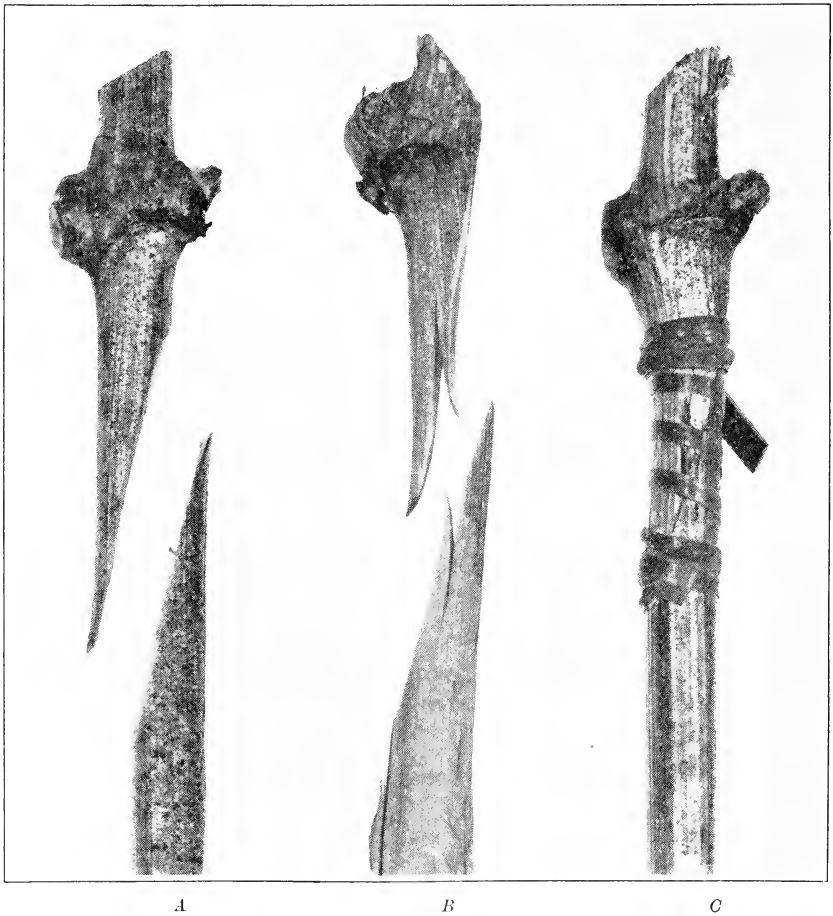
During the winter, nothing need be done to field-budded vines except staking or trellising, if that has not already been done. Because of the danger of damaging the buds in driving the stakes, it is best to stake the vineyard before planting the vines. The following spring, when the buds on the rootstock vines are swollen and nearly ready to break, the scion buds should be uncovered. The usual procedure is then as follows: Cut the rubber used for tying. Carefully examine the scion bud on each vine to ascertain that it is alive and grown fast to the stock; do not hesitate to apply considerable pressure to the bud chip, for if the union is good, the chip can hardly be dislodged by one's fingers. If the scion bud appears well united with the stock and is beginning to grow, cut off the stock 1 or 1½ inches above the bud. Place a building-paper sleeve about 1½ or 2 inches in diameter and about 9 inches long over the end of the stock and the scion bud, banking 3 or 4 inches of loose soil around the lower end of the sleeve to prevent the wind from blowing it away. Suitable sleeves may be made by rolling 9-inch squares of waterproof building paper in the form of tubes. This practice protects the buds and scion shoots from wind damage and also from rabbits and drifting soil. The sleeves also force the scion shoots to grow upright, and thus facilitate training. As soon as the scion shoot grows up through the sleeve, tie it to the stake. Remove all stock suckers and scion roots whenever they appear. If the scion bud is not good, the vine may be regrafted immediately or may be pruned back to one or two buds and then rebudded the next fall. In fertile, irrigated soils grafting is preferred; but in poor or unirrigated soils it is best to rebud the next fall.

Often stocks are killed by cutting them off when the scion buds are imperfect. Unless one has had considerable experience it is not easy to find all the poor unions. Rootstock rootings properly disbudded before planting usually grow only from the top or from the scion bud; hence if the top is cut off and the scion bud fails to grow, the vine is lost. To avoid this danger, the following method may be used.

About the time that the rootstock buds are ready to break, uncover the vines to expose the scion buds. Prune all the canes on each rootstock back to base buds. Cover the scion bud lightly (an inch) with loose soil, or place over it a building-paper sleeve. Watch the vines closely, going over the vineyard about once a week. As the scion buds start, cut off the tops of the rootstocks an inch or more above them. As the scion shoots grow, tie them carefully to the stake as in training any other vines. Thereafter keep the soil away from the base of the scion shoot to discourage scion roots, take off all stock suckers that start from the rootstocks, and *remove*

the rubbers after the lower parts of the scion shoots have hardened (May or early June).

Each time, in going over the vineyard, remove all shoots from the stocks on which the scion buds have not started. Sometime in May, when



A *B* *C*

Fig. 18.—The long whip graft: *A*, The sloping cuts made on the stock and scion; *B*, the tongues cut and opened out; *C*, the completed graft, tied, and ready for covering. (From Ext. Cir. 101.)

it is apparent that the remaining scion buds which have not started are probably defective, uncover all such, cut the rubbers, and examine the buds. Thereafter, allow the shoots to grow on all stocks that have defective scion buds. Rebud these next fall.

To regraft budded vines whose buds have not grown, or to correct plantings of mixed varieties, or to change the variety in an entire vine-

yard, the grafts commonly employed are whip, cleft, or groove (kerf or notch).

Whip Graft.—For vines less than ¾ inch in diameter the long whip graft (fig. 18) is perhaps best.

The sloping cuts are made at an angle of 15 to 25 degrees with the side of the stock or scion and must be the same length on both stock and scion. The tongue cut is started about one third of the distance from the point and ends at about two thirds of the distance from the point to the base of the cut. Opening out the tongues by bending them over with the knife as it is withdrawn aids in putting the scion on the stock. The parts are pushed together, tongues interlocking, until the cut surfaces coincide as completely as possible. If the stock and scion are of the same diameter, a good fit can be obtained all around. If one is larger than the other, one side must be fitted so that the cambium layers of stock and scion on that side coincide as completely as possible. The graft is then tied very firmly with budding rubber, raffia, or string. If rubber is used, it must be cut and removed after the graft has firmly grown together.

Cleft Graft.—Vines ¾ to 1½ inches in diameter are cleft-grafted most easily. The vine is sawed off so that about 2 inches of smooth, straight grain is left at the top of the stump (fig. 19, at *S*). If the sawing is done at or too near a place where the grain of the wood is crooked or curly, great difficulty will be experienced in obtaining a good fit.

Vines of fruiting varieties, grafted merely to change the variety, are usually sawed off 2 to 4 inches below the ground level. *When resistant stocks, however, are grafted to a fruiting variety the graft must be put in above the level of the ground;* if the grafting is done below ground, scion roots will form, and the resistant stocks may die. Resistant stocks are therefore cut off somewhere between ground level and 4 inches above it.

The top of the stump at the place where the scion is to be inserted should be trimmed smooth and clean with the grafting knife so that the line of the cambium layer can be easily seen. The stump is split to a depth of 1 or 1½ inches with the broad edge of a special grafting tool (fig. 19, *C*); a carpenter's chisel may be used instead but is less convenient. After splitting the stump, the grafting tool is removed; and the small end is placed in the cleft to pry it apart for insertion of the scion (fig. 19, *D*).

The scion is cut in wedge form, a little thicker on the side that is to be placed nearest the bark of the stock. The length of the wedge depends on the character and size of the cleft in the stock. The wedge—usually with a long taper—is so inserted that the line between the bark and

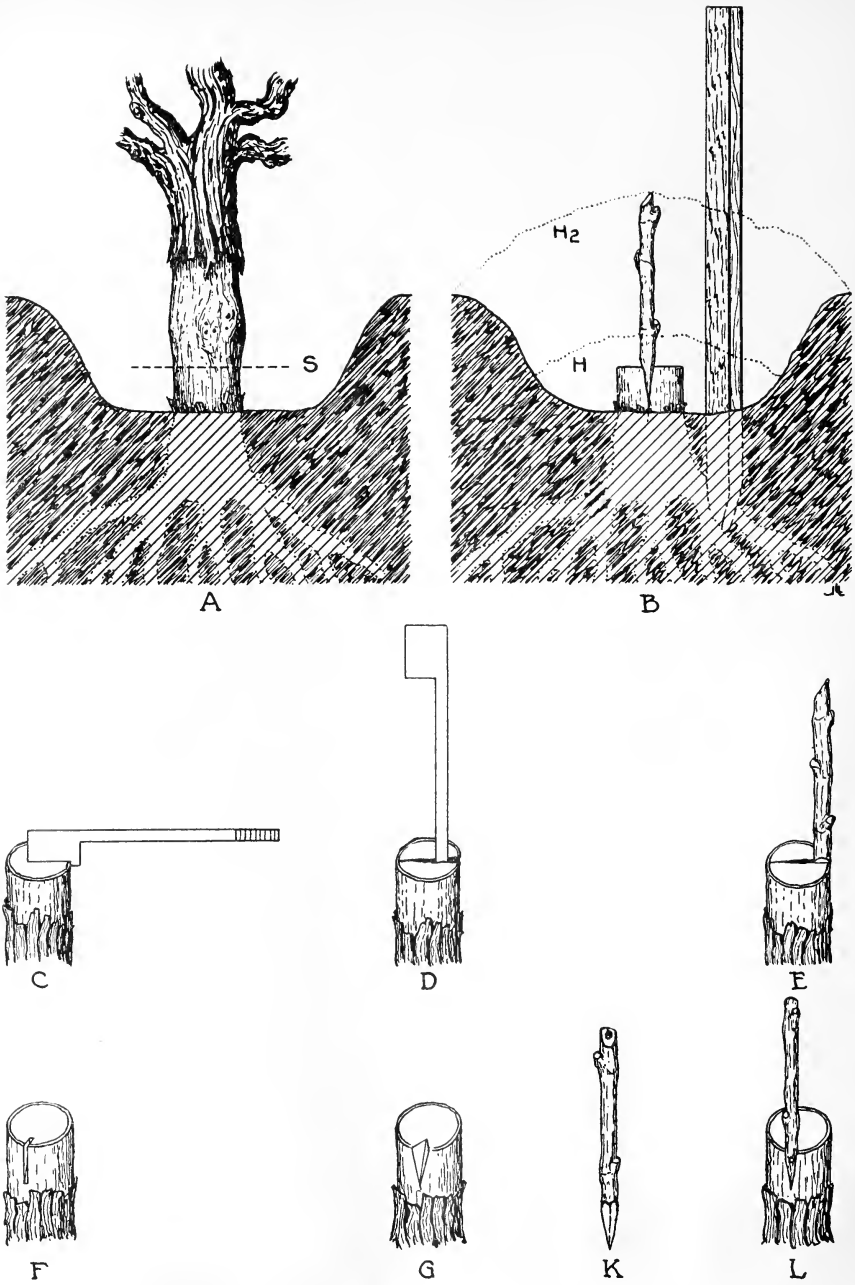


Fig. 19.—Operations in grafting: *A*, Where trunk is cut off; *C*, *D*, *E*, steps in cleft grafting; *F*, *G*, *K*, *L*, steps in groove grafting; *B*, the graft ready to be covered with soil. For details of operations see the text. (From Cir. 115.)

wood coincides with the corresponding line on the stock. This line is the position of the cambium layer. As the bark is thicker on the stock than on the scion, the outer surface of the scion will be set in slightly from that of the stock. Although the lines will seldom correspond exactly, satisfactory unions are obtained if these lines are very near together or cross in one or two places. Most grafters put the scions in at a slight angle, slightly in at the bottom and out at the top.

The scion should be cut with a sharp, clean knife and inserted in the stock immediately, before it has a chance to become dry even on the surface. One should therefore not prepare the scions beforehand. Scions of two buds are generally used.

If the vines are an inch or less in diameter, one scion to each vine is sufficient. To insert more will usually mean having two badly fitting grafts in place of one good one. For larger vines, two scions are preferable whenever both can be made to fit securely. If both of them grow, the weaker is removed at the next pruning. It will have served a good purpose in helping to heal the grafting wound.

To hold the scions firmly in place, vines less than 1½ inches in diameter must usually be tied with a few tight wraps of raffia, string, or budding rubber around the top of the stump. Larger vines need not be tied. Any rubber used for tying small vines should be removed after the grafts are firmly grown together.

Groove or Kerf Graft.—This differs from the cleft graft in the shape of the scion and the method of insertion. Instead of being wedge-shaped and inserted in a cleft or split, the scions are shaped to fit into a V-shaped groove on the side of the stock extending from the top of the stump downward for 1 to 1½ inches. The width and the depth at the top of the groove should be about the same as the diameter of the scion to be used. The groove tapers to a point at the bottom. The scion should be fitted into it so that the cambium layers of scion and stock coincide as completely as possible.

The groove in the stock is most conveniently formed by first making a shallow, straight saw cut as long and as deep as the groove is to be (fig. 19, *F*). Then, with a sharp knife, the groove is widened at the top and tapered to a point at the lower end (fig. 19, *G*). When finished, the cut surface should be smooth and straight, for if it is rough and irregular, a good fit with the scion cannot be secured. The angle formed at the bottom of the groove by the cut surfaces should be about 90°.

The scion should be so shaped that when it is placed in the groove, the cambiums of the stock and scion fit together. The angle that the cuts of the scion make with one another should be slightly more obtuse than

the angle of the groove. Thus, when the scion is placed on the stock, the contact will be firm at the line of the bark, insuring close contact of the cambium layers. Figure 19, *K* shows a scion properly shaped to fit the groove in the stock (fig. 19, *G*).

After insertion in the groove the scion should be held firmly in place until the tissues grow together. The easiest way is to nail with one or two 1-inch 19-gauge, flat-headed wire nails (fig. 19, *L*).

Length of the Scion.—Although it is usual to use scions of two buds, there is often an advantage in having them shorter or longer. On small vines that are whip-grafted, one good bud is sufficient; and only one shoot is allowed to grow in order that it may be vigorous and make a good cane from which to form the trunk of the vine. On large vines three and even more buds have been used with advantage: with only two buds the growth may be almost unmanageable, whereas with several buds the growth is divided between more shoots and they are less likely to grow so large as to be troublesome.

Covering the Graft.—As soon as the graft is finished the stake should be driven close to the vine, unless one is already there. The graft is then carefully covered at once with a wide mound of moist, well-pulverized soil. No wax and no covering other than moist soil need be used. The soil immediately around the scion should be put in place with the hands so that the position of scions is not disturbed. The scions are completely covered. If the weather is cool and moist and likely to remain so until the scions grow, merely covering the scions to their tips is sufficient. In the hot, dry weather of the interior valleys, however, scions should be covered to a depth of 2 or 3 inches in order to prevent them from becoming even slightly dry. When finished each graft will be in the middle of a wide mound of soil (fig. 19, *H*2); narrow mounds may not remain moist enough to insure that the graft will grow.

Proper management of the grafts in the first growing season is just as important as the grafting itself. The mounds should not be disturbed by hoe or cultivator until the unions are well formed. If the scions are completely covered and the mounds form a hard crust, this crust should be carefully broken with the fingers.

Suckering Grafted Vines.—Many large, vigorous shoots may come up from the stock. These, if left too long, will choke or dwarf the graft. If they are removed too soon, many good grafts will be killed by the breaking of the unions. When the grafts have started to grow vigorously, so that the shoots can be tied to the stake, it is safe to begin suckering. At this time the workman can sometimes pull up the suckers by hand without removing any soil. Unless he is certain, however, that they are not

entangled with the scion, he must carefully remove some soil and ascertain how to detach them without disturbing the union.

If grafts are slow in starting and if the suckers are vigorous, one must sucker before the scion has grown much. This can be done safely only by using extreme care.

Training Grafted Vines.—When the union is complete, the growth of the grafts on large vines is generally rapid—often an inch a day; many canes grow 15 feet or more by the end of the season. Unless this vigorous growth is properly managed, its benefits are lost, and it causes great trouble the following year. The shoots are managed exactly the same as on exceptionally vigorous, ungrafted vines.

Cost of Grafting.—The cost of grafting over an old vineyard is always heavy—between 7 and 15 cents per vine. In addition, one must consider the cost of cultivation, of stakes, and of losing the crop for one or two years. Grafting resistant rootstocks that have grown in the vineyard for only 1 or 2 years costs less than grafting old vines, but considerably more than fall budding.

HARVESTING TABLE GRAPES

Most of California's table grapes are marketed 2,000 miles or more from the vineyards. Transportation is principally in railway cars refrigerated with ice, and the time required is 7 to 11 days or more. The temperatures in the refrigerated cars afer the fruit is cooled usually average about 45° Fahrenheit. To market grapes successfully under these conditions requires care and skill in harvesting and packing to insure that the fruit leaves the shipping point in the best possible condition.

Grapes marketed within the state are not subjected to such a long journey. Varieties of somewhat poorer carrying qualities but of better eating quality, such as the Muscat, can therefore be placed on the local markets.

THE TIME TO PICK

In determining the best time or stage of development for picking table grapes, the chief considerations are as follows: (1) They should be attractive to the consumer in appearance and in eating quality; (2) they should keep and carry well; and (3) they should reach the market, if possible, while prices are high.

Ripening, as it interests the grower, consists largely in an increase in sugar, a decrease in acidity, and the development of characteristic color, texture, and flavor. These changes are continuous as long as the grapes remain on the vine, but practically cease as soon as they are picked. Under normal conditions there is a gradual improvement until the best stage is

reached for the purpose to which the grapes will be put, then a gradual deterioration. The optimum stage is the proper time to pick and for table grapes represents a compromise of the three considerations. The first—satisfaction to the consumer—should usually receive most emphasis. The second is really involved in the first, for the fruit must be good not only when picked but also until consumed. Except very early or late in the season, these requirements will usually have more influence on the price than will the condition of the general market.

Early in the season there is a tendency to market unripe fruit, which, though often sold for a high price, disappoints the consumer and ultimately depresses the market. The fact is recognized in the fruit and vegetable standardization laws of the State of California, enacted to promote the industry by preventing, as far as possible, the shipment of inedible fruit and fraudulent practices in packing and selling.

THE MEASUREMENT OF MATURITY

Of the changes involved in the ripening of grapes, only the content of sugar and acid can be measured accurately and conveniently. In a few cases color definitions can be given.

For practical purposes, the sugar content of ripe grapes is measured accurately enough with a hydrometer (saccharimeter). These instruments are generally calibrated in the Balling or Brix scale and read directly in per cent sugar by weight. The hydrometer measures specific gravity (weight per unit volume as compared with that of pure water). In ripe grapes sugar is the chief substance affecting specific gravity. In comparison with sugar, other dissolved substances have a small effect; hence the quantity of sugar present may be estimated by measuring the specific gravity.

Hydrometer Sugar Test.—To make a sugar test with a hydrometer proceed as follows: Choose a representative sample, 2 or 3 pounds or more, of the grapes to be tested. Thoroughly macerate by mashing the grapes in a pan or pail with the hands or a wooden masher or by passing them through a crusher. To press the juice from the pulp lay a square of cheesecloth over a pan or pail and pour the pulp upon it. Form a bag of the cheesecloth by gathering together the edges, and gently press it with the hands till sufficient juice is extracted. To make the test, pour the extracted juice into the cylinder to be used with the hydrometer. Fill the cylinder to overflowing so that the foam which forms as the juice is poured into the cylinder runs off. Gently insert the hydrometer, which should be clean and dry, into the juice until it comes to rest of its own accord. Read the stem of the hydrometer at the general level of the liquid

and not at the top of the meniscus. Carefully take the temperature of the juice. Observe the temperature of calibration printed on the hydrometer. If the temperature of the juice is higher than the calibration temperature shown on the hydrometer, add 0.33° Balling or Brix for each degree Fahrenheit difference in temperature (0.06 for each degree centigrade) ; but if it is lower, subtract the correction. The result—the corrected or true reading—is the approximate percentage of sugar.

Acid Titration.—To determine acid is more difficult. Using a pipette, measure 10 cubic centimeters of the clear juice into a flask of convenient size. Add 50–100 cc water[13] and one or two drops of phenolphthalein indicator solution. Slowly run a standardized solution of sodium hydroxide (0.133 normal) from a burette into the flask containing the diluted juice, constantly stirring or shaking the flask until a faint pink color is obtained that lasts 10 seconds or more. A solution standardized to 0.133 normal is equivalent to 0.01 gram tartaric acid per cubic centimeter.[14] The result is expressed in grams tartaric acid per 100 cc of juice. If the procedure is carried out as prescribed, the number of cubic centimeters of the sodium hydroxide solution used divided by 10 equals the tartaric acid in the juice in grams per 100 cc.

Balling-Acid Ratio.—The Balling hydrometer reading divided by the acidity, in grams per 100 cc,[15] gives the Balling-acid ratio—a better measurement of the palatability of table grapes than either the sugar content or the acidity alone. The minimum desirable Balling-acid ratio varies with different varieties. The Thompson Seedless, Malaga, and Ribier should be about 25 to 1—that is, 25 parts sugar to 1 part acid. The Ohanez, Cornichon, Muscat, and Emperor should be 30 to 1 ; the Tokay, Olivette blanche, and Red Malaga 35 to 1.[16]

Climatic conditions affect the relative amounts of sugar and acid, and their influence is reflected in the Balling-acid ratio: If the weather is very hot during the ripening period, the Balling-acid ratio will be high, and the grapes palatable at relatively low sugar. If the weather is cool, the acid will be higher, and more sugar will be required for equal palatability.

Judging Maturity in Picking.—Obviously the picker cannot test each cluster for sugar and acid. In judging maturity he relies chiefly upon

[13] Tap water, if reasonably pure, is satisfactory.

[14] The tartaric acid equivalent of ordinary 0.10 normal sodium hydroxide is 0.0075 gram tartaric acid per cubic centimeter.

[15] Sometimes per cent acid, grams acid per 100 grams solution, is used in this calculation. Grams acid per 100 cc is preferred because it is easier to obtain.

[16] Winkler, A. J. Maturity tests for table grapes. California Agr. Exp. Sta. Bul. 529:1–35. 1932.

the following characters: (1) Color and condition of the stem; if the main part of the stem that attaches the cluster to the cane is brown and woody, or if the stem framework of the cluster is of light straw or yellow color, the grapes are likely to be mature for table use. (2) Taste of the berries; the greenest grapes of a cluster—those near the apex—should be the ones chosen for tasting. Since the sense of taste is quickly dulled by frequent use, the picker must rely principally on other characteristics, using taste only occasionally when he cannot otherwise decide whether or not to pick a given cluster. (3) Appearance of the berries: Red or black grapes develop their characteristic color as they ripen. Although a well-colored grape is not necessarily ripe, yet when grown under the same conditions the best-colored grapes are usually the ripest. Green or white varieties become more nearly pale yellow or white as they ripen.

Not all the fruit in a vineyard nor even on the same vine ripens at the same time. Usually it is necessary to go over the vines three or more times in order to harvest most of the table grapes at the proper stage.

HARVESTING WINE GRAPES

The time for picking wine grapes depends to a considerable extent upon the kind of wine to be made. Grapes for dry wines should be of high acidity and moderate sugar content. Such grapes, therefore, are usually harvested after they test 18° Balling but before they reach 23°. For sweet wines the grapes should be high in sugar and low in acid. Grapes for sweet wines are allowed to attain as high a sugar content as is possible without raisining—usually 24° Balling or more.

For ordinary wines, all the crop is harvested at a single picking. This is the usual practice in California. For very fine wines, several pickings may be made in order to get the fruit uniform and all at the best possible stage of maturity. Even when the crop is all harvested at a single picking the clusters that have waterberry or redberry, those that are very green, and particularly those that are badly raisined, decayed, or moldy should be separated from the good fruit, since they may spoil a good lot of wine.

The grapes are usually picked into field lug boxes and hauled in them to the winery. The best practice is, of course, to crush the fruit and put it into the fermentation vats as soon as possible. If for any reason the grapes must be hauled a considerable distance or held for more than a few hours before crushing, then they should be picked and handled carefully. Broken and crushed grapes spoil quickly, and the organisms that

develop in them in the boxes may give the wine a bad odor and a high volatile-acid content. The use of dirty, juice-soaked boxes is always objectionable; and bulk hauling for long distances is undesirable.

PACKING AND SHIPPING GRAPES

The containers and methods of packing used for grapes to be shipped to eastern markets have been fairly well standardized. Throughout the harvesting and packing operations efforts are concentrated toward moving the fruit as rapidly as possible from the vines to the refrigerated cars to reduce deterioration to a minimum.

SHIPPING CONTAINERS

Most of the California table-grape crop is marketed in the so-called "display" grape lug. This package has the dimensions $5\frac{3}{4} \times 13\frac{1}{2} \times 16\frac{1}{8}$ inches (inside), the total depth ($5\frac{3}{4}$ inches) being made up in two parts—the lower part $4\frac{1}{2}$ inches; the upper part $1\frac{1}{4}$ inches. The lid is nailed on the box with no cleats other than the $1\frac{1}{4}$-inch top section. When one attempts to remove the lid, the entire top part comes off, leaving the box $4\frac{1}{2}$ inches deep. The box is filled as compactly as possible without damaging the fruit. Though the grapes settle during transit, the removal of the top $1\frac{1}{4}$-inch section with the lid leaves the remainder of the box completely filled and therefore suitable for display purposes; hence the name "display" lug.

Baskets, crates, or plain lug boxes of other dimensions and also sawdust lugs and kegs are occasionally used in the domestic markets. Sawdus chests measuring $7\frac{3}{4} \times 14\frac{15}{16} \times 18\frac{5}{8}$ inches (inside) are used for export.

For wine grapes shipped fresh to eastern markets the lug commonly used is $5\frac{1}{16} \times 13\frac{1}{2} \times 16\frac{1}{8}$ inches (inside). When lids are placed on these wine-grape lugs, a cleat $\frac{11}{16}$ inch square is used on each end beneath the lid.

MANNER OF PACKING

Table grapes in lugs are usually packed by the "stems up" method. To make this pack, tilt the box by placing one end of it crosswise in another box or by placing it on a special bench. Start packing by laying one or more clusters horizontally in the low end of the box. Continue filling from this end, placing all clusters nearly upright except such as may be necessary to make the bottom of the pack solid. Occasionally press the fruit toward the low end as the box is being filled so that when finished the pack is firm.

To pack a sawdust chest, first line it with a strip of paper of suitable width, placed crosswise in the box with the ends of the paper projecting a few inches above the sides of the box. Then put the proper quantity of grapes (usually 32 pounds) in the lined container, stems up or otherwise. Shake sawdust into and between the clusters by placing the box on a special vibrator (made for that purpose) while the sawdust is being run into the box from an overhead bin. Only specially prepared grape-packing sawdust is suitable for packing grapes. If the shaking is to be done by hand, place ¼ to ½ inch of the special sawdust in the bottom of the box. Then carefully put in a layer of grapes consisting of about half the total amount that is to go into the container. Cover the layer with sawdust, and rock the lug by alternately raising and lowering the ends about an inch, each time allowing the raised end to drop to the bench. This causes the sawdust to settle in among the grapes. Next, place the remainder of the grapes in the box as a second layer, into which shake more sawdust. Before nailing on the lid, lay the projecting ends of the paper lining over the top of the finished pack.

Wine grapes are usually "jumble-packed," the clusters being fitted into the box as best possible but with no regular order of arrangement.

PLACE OF PACKING

Grapes are packed either in the vineyard or in special sheds or houses. Both methods have their merits. Field-packing involves least handling and also least delay in getting the grapes into a refrigerated car for shipment. Given an adequate supply of skilled labor, favorable weather, and grapes in good condition, a shipper is likely to find it cheapest and probably the best. If, on the other hand, there are not enough skilled workmen for both picking and packing, or if the grapes require an unusual amount of trimming, or if the weather conditions are unusually severe, more uniform results may be obtained by repacking in a shed.

HANDLING AND TRIMMING THE CLUSTERS

The picker should grasp the cluster by the stem to remove it from the vine and to hold it up for inspection and trimming. He should cut the stem with a sharp knife or, better still, with picking shears. He should carefully remove all defective berries, particularly those broken or decayed, by cutting with shears the stem attaching the berries to the cluster. Under no circumstances should he pull the berry off with his fingers, leaving the wet brush attached to the cluster. The cluster is improved by removing all the undersized or insufficiently colored berries.

Since, however, the expense usually makes this work impracticable, only the worst of these off-type but sound berries are generally removed. Throughout the handling operations extreme care should be exercised to avoid crushing any berries or breaking them loose from the stems. Any break in the skin offers an easy entrance for molds, yeasts, and other decay-causing organisms.

PRECOOLING AND SULFUR DIOXIDE TREATMENT

The sooner the grapes are cooled after being removed from the vine, the better they will be when they reach the market. They may deteriorate as much in one day at a temperature of 85° or 90° Fahrenheit as in a whole week at 45°. The rate of cooling in the refrigerator car with only the normal circulation of air to carry away the heat from the fruit is very slow. Usually 3 or 4 days are required to cool the grapes in the top layer of the car below 50°. The use of car-precooling fans to increase the circulation shortens the time very much. The same results are obtained, but at a higher cost, by warehouse precooling.

If grapes are exposed to sulfur dioxide gas in the atmosphere, they will absorb it. A concentration of 15 to 25 parts per million of sulfur dioxide in sound table grapes greatly reduces the rate of deterioration. Ordinarily wine grapes require about 50 parts per million. Under actual operating conditions the best methods of application involve displacing the air in a standard refrigerator car or in some other treating chamber of similar size, with sulfur dioxide diluted with air to a concentration of approximately 2 per cent by volume. The ventilators and doors are then tightly closed, and the grapes absorb the sulfur dioxide from the mixture of sulfur dioxide and air. Sometimes sawdust-packed grapes are treated by mixing powdered sodium bisulfite with the special sawdust immediately before using it (5 grams of sodium bisulfite to each sawdust chest).

The chief benefit of the sulfur dioxide is its repressing effect on molds and other decay-causing organisms. It also assists in retaining the green coloring in the stems.

DRYING RAISINS

The clear, warm autumn weather of the middle and upper San Joaquin Valley permits the drying of raisins between the rows of vines in the vineyards, a method commonly known as natural sun-drying. About 85 per cent of the raisins of the state are sun-dried. Most of the remainder are dehydrated.

TIME TO PICK GRAPES FOR RAISINS

Grapes are usually considered ripe for raisins at 23° Balling or more. With the natural sun-drying process, the riper the grapes the better the raisins and the higher the yield, so long as there is no damage from rain; hence, although grapes harvested at 23° Balling make good raisins, those allowed to attain 24° or 25° will be even better. The degree of maturity at which to pick is usually a compromise between two considerations: first, the better quality and heavier yield obtained by allowing the grapes to ripen fully; second, the risk of unfavorable drying conditions if the grapes are allowed to hang on the vines too long. The earlier the grapes can be harvested, the greater the chances of drying them without interference from early fall rains. In the San Joaquin Valley they are usually allowed to attain a minimum of 23° Balling provided this occurs by the first of September. Most of them are picked by the middle of September regardless of the sugar content.

With grapes that are to be dehydrated, weather conditions are only a minor factor in the drying; and, furthermore, the influence of maturity on the quality of the raisins is less marked than with the natural sun-dried product. Even for dehydrated raisins, however, the grapes should be at least 21° Balling—preferably, indeed, between 23° and 26°. Harvesting must be completed before the early rains cause deterioration in the grapes.

SUN-DRYING

The grapes are picked into boxes or pails and then spread evenly on paper or wooden trays (2 × 3 feet), from 20 to 24 pounds of fresh grapes per tray. The fruit is spread on the trays without pretreatment of any kind; and when the top layer of berries has browned and shriveled (usually about a week later), the grapes are turned upside down onto another tray. When the grapes are two thirds to three fourths dried, wood trays are stacked, and paper trays are rolled. The raisins are allowed to continue drying in the stacks or rolls. When they have dried to the point where juice can no longer be squeezed out—16 per cent moisture or less—they are packed tightly into sweat boxes and hauled to central cleaning and packing-houses.

To prepare a good place for the trays, each alternate space between the rows in the vineyard is smoothed and leveled. Usually one space between two rows will furnish enough room for drying the fruit from both, leaving the alternate rows unobstructed. If the rows in the vineyard run north and south, one need merely level and smooth the space; but if they run east and west, the bed is best prepared so that it slopes

to the south, and thus give the grapes more direct exposure to the sun to hasten drying.

The three important raisin varieties—Thompson Seedless, Muscat, and Black Corinth—all may be dried by this method. The Black Corinth, however, ripens very early and, if the weather is hot, is best dried on stacked wooden trays with little or no direct exposure to the sun.

DEHYDRATION

In the San Joaquin Valley north of Madera County and in the lower Sacramento Valley, where temperatures are lower, the grapes ripen later than in the middle and upper San Joaquin, and early fall rains occur more frequently. In these districts it is somewhat hazardous to dry the raisins in the vineyard without pretreatment. Dehydrators are being used to a considerable extent, producing the "Golden Bleach" raisins. First the grapes are dipped into a solution containing from 0.2 to 0.5 per cent lye (sodium hydroxide) at a temperature near boiling. Then they are cooled by dipping into cold water. The length of the hot dip—usually one or two seconds—depends upon the strength of lye, the temperature, and the maturity of the grapes. They are dipped until very faint checks show in the skins of the berries after they have been cooled by rinsing. After dipping, the grapes are spread on trays and exposed to the fumes of burning sulfur until the green color has bleached to a yellowish white, usually 2 to 4 hours. Then they are dehydrated at 140° to 160° Fahrenheit. The product—a light, brilliant, golden yellow—is very attractive. As the raisins taste strongly of sulfur dioxide, they are unpalatable for eating out of hand; but when they are used in cooking or baking, the sulfur dioxide is so diluted that it is neither noticeable nor harmful. The Golden Bleach product of California competes in foreign markets with the "Sultana" raisins of Australia and the "Smyrna" raisins of Asiatic Turkey. Though the quality is inferior to that of the Sultana, the cost of production is much lower.

DISEASES AND PESTS

California is free from many of the serious fungus diseases and insect pests that trouble the industry elsewhere. Several, however, are present and must be controlled for successful operation of a vineyard.

POWDERY MILDEW[17]

This disease, also called oidium in other grape-growing regions, is caused by a fungus that may grow on all green parts of the vine. It ap-

[17] For a more complete discussion see: Jacob, H. E. Powdery mildew of the grape and its control in California. California Agr. Ext. Cir. 31:1–17. 1929.

pears on the surface of affected parts as a grayish-white, powdery growth which, when rubbed off, leaves weblike black or dark-brown discolorations. It causes curling and withering of the leaves in spring and early summer; dropping, discoloration, or splitting of the berries; blackening and poor maturity of the canes. It is present in every grape-growing region of the state. Its seriousness depends upon the weather—unless it is artificially controlled. Measures should be taken against it in all seasons and in all regions except perhaps the hot desert. It is prevented by dusting the vines with very finely divided sulfur, usually by means of knapsack or power machines. Where, however, only a few vines are to be dusted, the sulfur may be placed in a coarse cloth bag, which is then shaken on the windward side of a vine so that the cloud of sulfur formed will drift over and through the vine. The first application should be made when the shoots are 6 or 8 inches long, the second when they average 15 to 18 inches, and the third when they reach 2 or 3 feet. These three applications will usually prevent mildew in early-ripening vineyards of the San Joaquin or Sacramento valleys and the south coast region. In the intermediate valley and north coast regions and for late grapes elsewhere, a fourth application should be made when the berries are about the size of buckshot, and perhaps a fifth application when they are half grown or just beginning to ripen. In the hot desert region one application, when the shoots are 18 to 24 inches long, may suffice. If experience in that region shows one treatment to be insufficient, then a first application should come when the shoots are 15 to 18 inches long; a second when they reach 2 or 3 feet.

BLACK MEASLES (ESCA)

Old vines are often attacked by a fungus that enters through pruning wounds and destroys the old wood in the trunk or large arms. The vine shows little effect until the decay reaches the outer active layers. Then the growth weakens; the leaves become yellow or brown in patches between the veins; the grapes become spotted with small, purplish dots or shrivel and dry; and finally the vine may perish, often suddenly. The disease may be controlled, or at least temporarily checked when the first symptoms appear, with a spray consisting of 4 pounds of sodium arsenite[18] in 100 gallons of water. The spray is applied to the dormant vines but not within 2 or 3 weeks after pruning. It may be used safely before pruning. The specific sign of this disease is the dry, rotten wood (punk) in the trunk or large arms. All other symptoms mentioned may be found associated with other diseases not controllable with this spray.

[18] Sodium arsenite for this purpose is usually sold as a heavy solution containing the equivalent of 6 pounds sodium arsenite per gallon.

BLACK KNOT

The organisms (bacteria) that cause crown gall on other trees and shrubs produce black knot on grapevines. The growth of the bacteria causes a proliferation of the cells in the local area of attack, resulting in spongy swellings that are at first greenish brown but which later die and become black (whence the name). The disease is most prevalent on vines injured by winter freezing. As it seldom causes serious damage, little or no effort is usually made to control it except to avoid spreading it by cutting into the galls with pruning tools or any other implements that will be used on healthy tissues. If one desires to remove the knots, he should carry a special knife, shears, or hatchet for the purpose.

PIERCE'S DISEASE (CALIFORNIA VINE DISEASE)

This is a disease of apparently virus nature that caused widespread destruction in the vineyards of southern California and in the Santa Clara Valley during the latter part of the nineteenth century. At the present time, it makes the growing of vinifera varieties almost impossible in parts of the south coast region. The disease has now invaded the San Joaquin and Sacramento valleys and parts of other areas. The symptoms differ with the variety. With Emperor, Malaga, and Red Malaga the most striking symptom is the failure of badly affected vines to leaf out in the spring. Less severely affected vines do leaf out and produce a relatively weak growth characterized by a peculiar mottling and marginal burning of the leaves; wilting and shriveling of the fruit; and irregular maturing of the canes. The vines die from the disease—Ribier usually within a few months, other varieties from three to five years or longer after the first symptoms appear. No control is known.

LITTLE-LEAF

The principal symptoms of the little-leaf disease on grapes are the following: The color of the leaves in midsummer and late summer becomes variegated. The areas immediately adjacent to the large veins remain green while the remainder of the leaf becomes whitish-green to whitish-yellow. The leaves become misshapen. Whereas the normal leaf blade of the grape is broad, usually three- or five-lobed and symmetrical, the leaves of affected vines become narrow, often losing their characteristic lobing and bilateral symmetry. As the name implies, the leaves remain smaller than normal, the size depending on the severity of the condition. In extreme cases the leaves may be less than one-tenth normal size. On severely affected vines the shoots have shortened internodes. Where this

condition is strongly marked, the shoots may become zigzag. Badly affected vines are severely stunted, producing little or no crop. The clusters tend to be straggly and to have many shot berries.

This disease, which appears to be the same as the little-leaf of deciduous tree fruits, is remedied or helped by the application of zinc. The best method of application on spur-pruned vines is to paint or swab the pruning wounds with a solution of zinc sulfate in water. On cane-pruned vines this treatment, though helpful, has not proved adequate for severe cases. The solution must be applied before the pruning wounds become dry. Treatment early in the season appears to be more effective than later, after the vines begin to bleed. Solutions of 2 pounds of zinc sulfate to each gallon of water have produced very good results in some vineyards, but in others have badly damaged the spurs. Probably 1½ pounds per gallon would be safer; but this strength might sometimes be ineffective.

PHYLLOXERA[19]

In California this insect, related to the aphids and scales, attacks only the roots of vines. It causes serious trouble, for, once a vineyard is infested, little or nothing can be done, and the vines usually die out in from three to ten years. On the young rootlets, the feeding of the insects causes small swellings, giving them a characteristic contorted appearance and checking their growth. On the larger roots are formed small galls which later decay and disrupt the functioning of the roots.

Although control in an established vineyard is well-nigh impossible, new vines can be grown in infested soil by using rootstocks resistant to the phylloxera. The establishment of such vineyards is discussed under "Propagation."

In the north coast region, which is rather generally infested, there are only a few areas where vines can be grown on their own roots. In the Sacramento and San Joaquin valleys, and in the intermediate valley region, infested areas are scattered, and most of the vineyards are still free. In southern California, only a few small attacks have been reported, and most of these were cleaned up by removing the vines. In the San Joaquin Valley the most seriously affected areas are in Fresno and Tulare counties, and in these areas resistant stocks must be used. The trouble is more serious in heavy than in light soils; vines growing in very sandy soils may not be seriously affected. Irrigated vines usually survive longer than unirrigated.

[19] A thorough discussion of this insect and its life history may be found in: Davidsen, W. M., and R. L. Nougaret. The grape phylloxera in California. U. S. Dept. Agr. Bul. 903:1–128. 1921. (Out of print.)

Once an area becomes thoroughly infested, the insect remains there as long as grapevines exist. It may be effectively kept out of noninfested lands by proper enforcement of the regulations governing the legal movement of vines and soil. The insect may be spread by infested nursery stock, by drainage and irrigation water, and by tillage implements, tractors, trucks, and even picking boxes.

Rootstocks Resistant to Phylloxera.—Certain American species of grapes are highly resistant to phylloxera. By selecting certain varieties from the native species and by artificially hybridizing between species, numerous resistant varieties of rootstocks have been developed. A few of outstanding promise are furnishing the foundation for the reconstruction of vineyards. As they are further tested, some may be discarded and replaced with others that are still to be developed.

In the north coast region the Rupestris St. George is used almost exclusively. It is recommended as a fairly satisfactory stock for vigorous, heavy-bearing varieties such as Carignane, Zinfandel, Palomino, Sauvignon vert, and Burger, when grown on deep, friable, well-drained soils of the valley floors and rolling land. On wet land one of two other stocks, Mourvedre × Rupestris 1202 and Aramon × Rupestris Ganzin No. 1, will probably do better. No stocks are known to be suited to the dry, shallow, hillside soils. The St. George is also apt to prove unsatisfactory with shy-bearing varieties, particularly if the shy bearing is caused by failure of the flowers to set. With such varieties the stocks Riparia × Rupestris 3309, 3306, and 101–14 will probably prove more satisfactory.

In the Sacramento, the intermediate, and the San Joaquin valley regions the 1202 and A × R No. 1 are well suited to wine-grape varieties in general and to the Thompson Seedless for raisin production. For table grapes and for the Muscat of Alexandria, no tested stocks have proved entirely satisfactory. The 1202 and A × R No. 1, also certain others, produce good vines that bear good crops of fair-quality fruit. Other promising stocks are being tested. In general, however, the fruit from vines on resistant rootstocks has been inferior to that from vines grown on their own roots in noninfested soils. Until a major portion of the soils used for table grapes are infested, the grafted vineyards must compete directly with those not grafted.

NEMATODE

In very sandy soils heavily infested with the root knot nematode it may be impossible to grow grapes except by grafting them on nematode-resistant rootstocks. The nematodes are small, true worms that bore into

the roots and live there. They cause swellings and distortions that, on superficial examination, may sometimes be mistaken for those caused by phylloxera. Though apparently all varieties of vinifera grapes are susceptible, there appear to be slight differences in the severity of nematode attacks. Thompson Seedless will do fairly well in some soils where Red Malaga and Ribier are failures.

Rootstocks Resistant to Nematode.—The rootstock problem for nematode is still relatively new and by no means solved. The stocks that are highly resistant and most promising are Dogridge, Salt Creek, Solonis × Othello 1613, Solonis × Riparia 1616, and perhaps also the Berlandieri × Riparia 420–A. Of these the first four have proved very highly resistant though not immune. The last-named appears sufficiently resistant to grow under all but the most extreme conditions. In very sandy soil where the nematode is worst, the little-leaf disease is also usually bad. Furthermore, vines grafted upon these nematode-resistant rootstocks appear slightly more susceptible to little-leaf than vines on their own roots.

Although these stocks cannot yet be recommended for general vineyard planting, they do appear worthy of trial in any vineyard so badly infested with nematode that the vines do not grow satisfactorily on their own roots.

GRAPE LEAFHOPPER[20]

During certain periods the grape leafhopper has severely injured the vineyards of the San Joaquin Valley and other regions. It appears to increase and decrease in cycles. This insect is whitish green, about 1/10 inch long, and injures the leaves by sucking out their juices, causing minute round, whitish spots on the leaves. When abundant it causes the leaves to drop prematurely. It also soils the fruit with the black specks of its droppings. There are usually two or three broods in the season, with the insects overwintering in the adult stage.

The three materials listed below, each applied at a different season and at a different stage of the hopper's development, may be used in control.

Pyrethrum.—In the early spring, after the green shoots appear, the overwintering adults seek the green shoots to feed and to lay eggs. At this time they may be killed and effective control accomplished in isolated vineyards by spraying with an oil solution of pyrethrum, applied with special atomizing equipment, and not with an ordinary spray rig. Only about 2 gallons are required per acre.

Nicotine.—The wingless nymphs of the first brood appear in May and

[20] A complete discussion of this insect, its life history and methods of control may be found in: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. 1933.

early June. Just as the oldest nymphs are growing wings, the vines may be treated with a spray consisting of 1 to 1½ pints of nicotine sulfate (40 per cent) per 100 gallons of water, together with an appropriate spreader such as soap. The effectiveness of the spray is increased by adding a little lye or soda ash to make it alkaline. During application, care must be taken to wet the hoppers on the lower sides of the older leaves. To do an effective job, the spray from the nozzles must be directed upwards.

Calcium Cyanide.—Late in the season, when most of the hoppers are adult and very numerous, treating the vines with calcium cyanide dust is effective. This dust should be applied with power machinery, and the weather conditions must be favorable—that is, with no wind and with fairly high humidity. In the San Joaquin Valley such conditions are most frequently obtained in the early part of the night.

As calcium cyanide dust produces a poisonous gas it should be handled with care. The operators of the dusting equipment should be provided with adequate gas masks. This material should not be applied with horse-drawn dusting machines or in the immediate vicinity of farmyards containing poultry or livestock.

CUTWORMS

The cutworms, larvae of certain night-flying moths, usually remain in the ground during the day but come up the vines at night to chew off the opening buds or the tender young shoots. They are controlled by putting a ring of tanglefoot or other similar sticky preparation around the base of each fruit spur or fruit cane, and also around trellising stakes or other objects up which they might climb. They will not pass the band of sticky material.

RED SPIDER

The Pacific mite has been very injurious in certain localized areas in the lower San Joaquin Valley, the intermediate valley region, and the north coast region. The adults, having overwintered beneath the rough bark on the trunks and arms of the vines, emerge in the spring and migrate to the new shoots. As the season advances, the population increases, until by mid- or late summer the mites may become so numerous as to injure the vines severely, even causing the leaves to drop completely before the fruit is ripe. Weather and general environmental conditions that favor or hinder the growth of the vines have, apparently, considerable influence on the development of the mites and the seriousness of the damage.

Although several materials appear promising, no altogether satisfactory means of control has been worked out. A summer oil emulsion spray

applied when the shoots are only 2 or 3 inches long is fairly effective in killing the mites. (The vines must not be sprayed with oil after they have been sulfured.) Another considerable help is a ring of permanently sticky material placed around the base of each fruit spur or fruit cane before the buds break. Soon after the buds break and before the shoots are more than a couple of inches long, the shoots that arise below the bands of the sticky material must be removed, taken from the vineyard and destroyed. Most of the mites are destroyed with the water sprouts.

In experimental tests,[21] a proprietary preparation containing selenium (Selocide) has proved effective. It is applied as a summer spray diluted 1 to 500 with water. To each 100 gallons of diluted Selocide are added from 2 to 5 pounds of wettable sulfur and ½ pound of casein or blood-albumin spreader.

GRAPE LEAF ROLLER

Sporadic occurrences of the grape leaf roller have sometimes assumed serious proportions. The presence of the insect in a vineyard may be detected by the characteristic rolling of the leaves, one edge being rolled up rather tightly to about halfway across, making a tube (somewhat less than the diameter of a lead pencil) in which the insect lives. In the middle San Joaquin Valley there are apparently three broods a season.

No entirely satisfactory control program has been developed. In experimental tests, promising results have been obtained by applying fluosilicate dusts soon after the berries have set.

RABBITS

Rabbits are frequently destructive in newly planted and young vineyards. They come back to the same spot night after night, eating off the leaves and eventually killing the vines or weakening them severely. The most effective control is obtained by fencing the young vineyard with rabbit-proof wire netting 2½ feet high above the ground and extending a few inches into the ground. If the rabbits are not very numerous and if only occasional vines are attacked, these vines may be sprayed with a heavy suspension of arsenate of lead, which will cause the rabbits to avoid them. For this purpose 1 pound of powdered lead arsenate is used to each 10 gallons of water. Slaughterhouse blood is also effective when spattered on stakes, clods, and other objects near the vines.

[21] Hoskins, W. M., A. M. Boyce, and J. F. Lamiman. The use of selenium in sprays for the control of mites on citrus and grapes. Hilgardia 12(2):113–75. 1938.

GOPHERS

Young vines may be severely injured or killed by gophers, which girdle them just below the surface of the ground. These pests may be trapped, or poisoned by conventional methods. Information can be obtained from the office of the county agricultural commissioner or farm advisor.

THE GRAPE VARIETIES OF CALIFORNIA

Probably 6,000 to 8,000 varieties of grapes have been named and described. In California about 10 per cent of this horde are growing somewhere in the vineyards, gardens, and variety collections, though not more than 40 or 50 can be considered as important commercial varieties. The list is constantly undergoing readjustment. As the new varieties prove better suited to our purposes, the old ones are gradually displaced.

In the following paragraphs an attempt has been made to give the purpose, importance, adaptability, and a brief horticultural description of each of the most common commercial varieties of raisin, table, and wine grapes now being grown in California. Long, detailed, technical descriptions have been purposely avoided. The photographs in figure 20 illustrate various berry shapes.

RAISIN GRAPES

Thompson Seedless (Sultanina).—Well over half the world's raisins and about 80 per cent of the raisins of California are made from this variety, which originated in Asia Minor and was first grown in California by Mr. William Thompson near Yuba City. It is called Oval Kishmish in the eastern Mediterranean regions, Sultana in Australia and South Africa.

In California about one third of the total grape acreage is Thompson Seedless. Besides being the principal raisin variety it is the leading table grape; but for the production of table grapes the vines are usually girdled to make the berries larger and to improve shipping quality. From it are also made large quantities of white sweet wines and much distilling material to furnish alcohol for fortifying other sweet wines.

The clusters are large; heavily shouldered, long cylindrical; and well filled. The berries are uniform, medium-sized; ellipsoidal elongated; greenish white to light golden; always seedless; firm and tender in texture; neutral in flavor; very sweet when fully ripened; and moderately tender-skinned. As the berries are somewhat weakly attached to the stems, causing the clusters to "shatter" in transit, the shipping quality of the fresh grapes is only fair. The ripening period is early midseason.

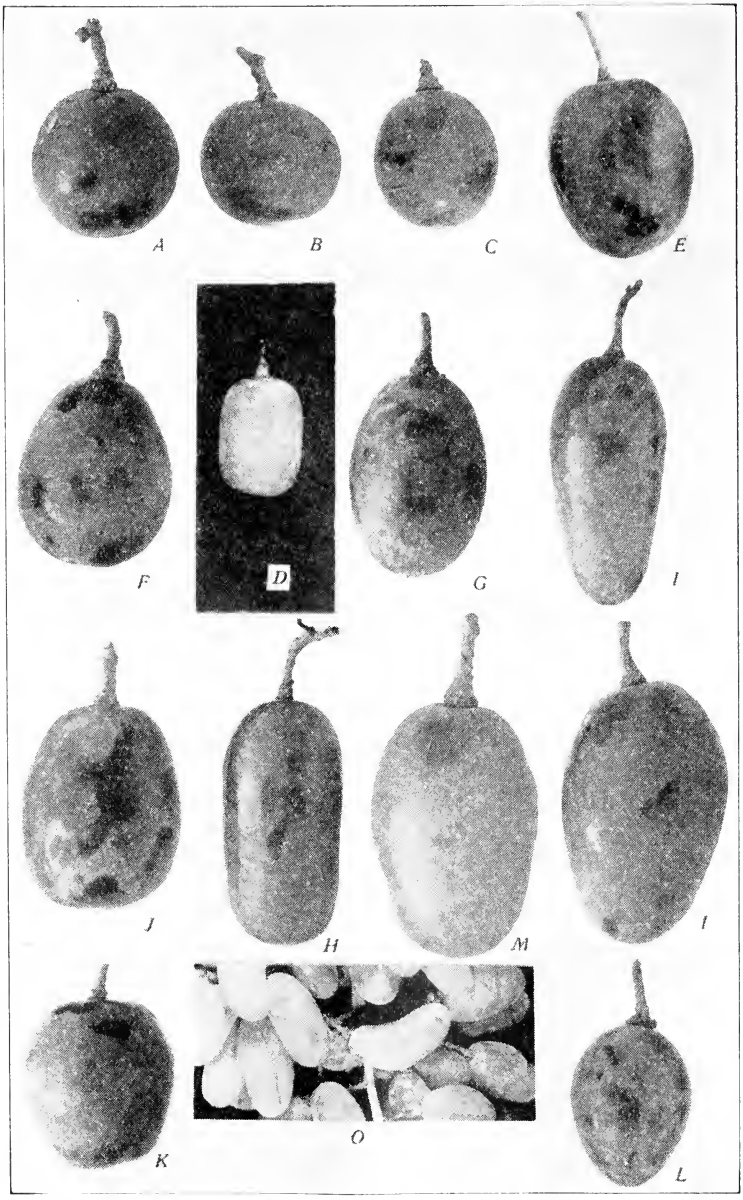


Fig. 20.—Grape berry shapes: *A*, Spherical; *B*, oblate; *C*, ellipsoidal; *D*, cylindroidal; *E*, ovoid; *F*, obovoid; *G*, ellipsoidal elongated; *H*, cylindroidal elongated; *I*, ovoid elongated; *J*, obovoid elongated; *K*, ovoid truncated; *L*, ovoid pointed; *M*, fusiform; *O*, falcoid elongated. (From Hilgardia vol. 11, no. 6.)

The grapes dry easily into raisins of soft texture and excellent quality. The vines are very vigorous and very productive. Cane pruning is required.

The Thompson Seedless is well adapted to all parts of the San Joaquin Valley where grapes are grown and to the warmer parts of the Sacramento Valley. In the hot desert it does better than any other variety tried. It is unsuited to the cooler regions.

A pink variation—Sultanina rose—is of interest for home use. Except for its pink or rose color it is almost identical with the Thompson Seedless.

Muscat of Alexandria.—This is a very old variety of North African origin, from which are made the raisins of Spain—the cluster "Malagas" and the stemmed "Valencias" or "Muscatels." About 15 per cent of the California production of raisins is Muscat, and it is also an important raisin variety in Australia.

As a table grape it is highly esteemed for home gardens and local markets. Its delicious flavor, large size, and juicy, but not watery, pulp make it a favorite with nearly all who are familiar with it. Although it has fair shipping qualities, the bloom is easily rubbed off in handling, leaving exposed the dull-green, ground color. It lacks the attractive appearance necessary in stimulating sales of any fresh fruit and is therefore relatively unimportant in table-grape shipments to eastern markets.

As a wine grape the Muscat of Alexandria is extensively used for the sweet fortified Muscatel wine now so popular. Much of the crop is used for this purpose. Dry wines made from it are mediocre or inferior because it lacks high natural acidity.

The clusters are medium-sized; shouldered, conical; and loose, often straggly. The berries are large, obovoid, dull green, normally seeded, pulpy, and strongly aromatic (Muscat) flavored. The moderately tough skins are covered with a gray bloom, easily rubbed off. The ripening period is late midseason, and the grapes dry easily into large raisins of soft texture and excellent quality. The vines are medium in vigor and very productive; they are usually head-pruned. In some regions and in many soils, particularly those that are sandy, the flowers set poorly, resulting in straggly clusters, many shot berries, and frequently poor crops. Often the setting of the flowers can be improved by painting the pruning wounds with zinc sulfate as recommended for little leaf, or by longer pruning and flower-cluster thinning.

The Muscat of Alexandria is adapted only to hot regions. It thrives in most of the grape-growing areas of the San Joaquin Valley, the warm parts of the Sacramento Valley, and the warm valleys of the south coast

region. It is not suited, however, to the hot desert because of its tendency to sunburn under conditions of extreme heat.

A pink variation—Flame Muscat—unimportant in California, is grown in South Africa under the name Red Hannepoot.

Black Corinth (Zante Currant).—For over five hundred years Black Corinth raisins have been made in Greece, where the variety probably originated and where most of the world's supply is still produced.

The clusters are small to medium in size; winged, uniformly cylindrical; well filled to compact when the vines are girdled, but straggly from ungirdled vines. The berries are very small; spherical to oblate; dark reddish black; mostly seedless, with an occasional seeded berry of medium size; very juicy; neutral in flavor; and very thin and tender-skinned. They ripen early and dry easily into very small raisins of soft texture, pleasing tart taste, and superb quality.

The vines are vigorous and—if girdled—productive. In California they are usually cane-pruned.

The Black Corinth is well suited to the central and lower parts of the San Joaquin Valley. It has also done very well in experimental plantings at the University Farm, Davis.

Seedless Sultana (Round Seedless, Round Kishmish).—This grape resembles the Thompson Seedless but differs in having smaller, spherical or oblate berries, a few of which contain partly hardened seeds. It has been largely displaced by the Thompson Seedless.

TABLE GRAPES

Thompson Seedless.—For discussion of this variety, see "Raisin Grapes."

Flame Tokay.—Formerly the Flame Tokay was California's premier table-grape variety. It is now second to Thompson Seedless. It owes its importance primarily to its brilliant red color and to its splendid shipping and keeping qualities.

The variety apparently originated in Kabylia, a province of Algeria, where it is known by the Arab name of Ahmeur bou Ahmeur.

The clusters are large; shouldered, short conical; and compact. The berries are large to very large; ovoid truncate; brilliant red to dark red; normally seeded; very firm; neutral in flavor; thick, fairly tough-skinned. The stems are large and tough, and the berries adhere firmly. The grapes ripen in late midseason. They are sensitive to sunburn. The vines are usually head-pruned.

The principal producing area is around Lodi in the intermediate valley region. There are other areas of lesser importance in Sacramento County, and a few scattered commercial plantings elsewhere in the state.

In the hotter regions the variety does not color well and sunburns badly, whereas in the cooler coastal sections it does not ripen well.

Emperor.—The origin of the Emperor is unknown. Third in popularity as a table variety, it owes its importance to its late ripening, its attractive appearance, and its excellent shipping and keeping qualities. Some Emperors are held in cold storage to extend the marketing season.

The clusters are large in size; long conical; and well filled. The berries are uniform, large; elongated obovoid or ellipsoidal; light red to reddish purple; normally seeded; moderately firm; neutral in flavor; thick and tough-skinned. The stems are tough, and the berries adhere very firmly. The variety ripens late. The vines are very vigorous and productive. They are cordon-pruned; often short cordons are supplemented with short fruit canes at the ends of the branches.

The Emperor is profitable only when it attains a red color and a large berry size. It most nearly attains perfection near the foothills along the east side of the San Joaquin Valley in Tulare and Fresno counties. About 90 per cent of the commercial Emperors are produced in this area.

Malaga.—The Malaga, once California's leading table-grape variety, has been displaced from this position largely by the Thompson Seedless (from girdled vines).

The clusters are large to very large; conical; and well filled. The berries are uniform, large; ellipsoidal; whitish green to whitish yellow; normally seeded; firm; neutral in flavor; thick, moderately tough-skinned. The stems are tough, and the berries adhere firmly. Shipping and keeping qualities are very good. The vines are vigorous and very productive. Although cordon pruning is best, head pruning is satisfactory. The ripening time is midseason.

The Malaga, being suited only to the warmer regions, is grown in various parts of the San Joaquin Valley and in the hot desert.

Red Malaga (Molinera).—This is a Spanish variety grown in Spain under the names Molinera Gordo and Castiza. In California it provides the market with a red table grape suited to warmer regions and ripening earlier than the Flame Tokay.

The clusters are very large; widely branched and irregular in shape; and loose to well filled. The berries are large; spherical to short ellipsoidal; pink to reddish purple, often faintly striated; normally seeded; very crisp and hard; neutral in flavor; low in acidity; tender-skinned. The stems are tough; the berries firmly attached. Shipping and keeping qualities are fair. The vines are very vigorous, and productive when cordon-pruned or long pruned and flower-cluster-thinned. The grapes ripen in midseason, usually just ahead of Malaga.

The Red Malaga is well suited to most of the San Joaquin Valley region, where it ripens earlier and can be marketed before the Flame Tokays of the intermediate valley region. After the Tokays start to move, the demand for Red Malaga rapidly decreases.

Ribier (*Alphonse Lavallée*).—This beautiful table grape, misnamed in California, is one of the finest of the European hothouse varieties; the grape grown in California is the Alphonse Lavallée and not the Gros Ribier of Europe. Although the principal black table grape in the state, in total production it ranks only sixth among all table-grape varieties.

The clusters are medium in size; short conical, often heavily shouldered; varying from loose to compact. The berries are very large; oblate to ellipsoidal in shape; jet black; normally seeded; firm; neutral in flavor but mildly astringent; low in acid; and moderately tough-skinned. The stems are tough, and the berries firmly attached. The shipping quality is good; the keeping quality excellent. The vines are moderately vigorous and productive. They are cordon-pruned. The fruit ripens in midseason.

The Ribier is best suited to the warm middle and upper San Joaquin Valley.

Almeria (*Ohanez*).—Spain produces and exports large quantities of this late table grape, packed in granulated cork. The variety is not of great importance in California because of its susceptibility to Ohanez spot, apparently a form of heat injury.

The clusters are medium or medium large; short conical; and well filled to compact. The berries are medium large; cylindroidal; greenish white; normally seeded; firm; neutral in flavor; thick and tough-skinned. The stems are tough, and the berries firmly attached. Shipping and keeping qualities are excellent. The vines are vigorous, and usually productive when allowed to develop large size and cane-pruned. The variety does best when trained on arbors. Artificial pollination may sometimes be needed. The fruit ripens late.

The Almeria has been successful only in local areas in Tulare County, on the east side of the San Joaquin Valley.

Cornichon (*Olivette Noire*).—The production of Cornichon has gradually decreased until now it has only a minor importance.

The clusters are medium to large; conical, often winged; and well filled. The berries are large; ellipsoidal elongated; reddish black with abundant bloom; soft and juicy; neutral in flavor, thick and tough of skin. The shipping and keeping qualities are only fair. The vines, though vigorous, tend to bear irregularly. The fruit ripens in late midseason.

The Cornichon does best in the intermediate valley region.

Olivette Blanche.—The very large size and regular elongated shape of this table grape make it one of the most beautiful. Because of its fragility and poor shipping quality, it is of only minor commercial importance.

The clusters are very large; irregular conical; and well filled. The berries are very large; uniform ovoid elongated, almost pointed; bright greenish to greenish white, often with a pink blush; neutral in flavor;

TABLE 1

LESS-KNOWN TABLE-GRAPE VARIETIES

Variety	Period of maturity	Color of berry	Size of berry	Shape of berry	Special characteristics
Black Hamburg	Medium	Black	Large	Spherical	.....
Black Prince	Medium	Black	Large	Spherical	Crisp texture
Chasselas doré	Early	White	Medium	Spherical	.....
Chasselas rose	Early	Red	Medium	Spherical	.....
Damas rose	Medium	Red	Very large	Spherical	Soft texture
Danugue	Late	Black	Large	Spherical	Very large clusters
Dattier	Medium	White	Large	Ellipsoidal	.....
Ferrara	Late	Reddish-black	Large	Ellipsoidal	Good keeping qualities
Flame Muscat	Medium	Pink	Large	Obovoid	Muscat flavor
Gros Colman	Medium	Black	Very large	Spherical	.....
Italia	Late	White	Very large	Ellipsoidal	Muscat flavor
Khandahar	Medium	White	Very large	Cylindroidal	Brittle stems
Milton	Late	Black	Large	Spherical	Good keeping qualities
Monukka	Medium	Reddish-black	Medium	Ellipsoidal	Seedlessness
Muscat Hamburg	Medium	Black	Medium	Ellipsoidal	Muscat flavor
Pearl of Csaba	Very early	White	Medium	Spherical	Muscat flavor
Prune de Cazouls	Late	Black	Large	Ovoid	Tough skins
Sultanina rose	Medium	Pink	Medium	Ellipsoidal	Seedlessness

low in acid; firm and tender; thin-skinned, easily bruised, and inclined to discolor where bruised. The stems are somewhat brittle. The vines are very vigorous, and productive if cane-pruned. The fruit ripens in midseason.

The Olivette blanche does well in all grape-growing areas of the San Joaquin and intermediate valley regions.

Rish Baba.—The beautiful appearance and odd shape of this variety, of Persian origin, has given it about the same importance as the Olivette blanche. Both have been indiscriminately marketed as "Lady Fingers." Both have essentially the same merits and defects.

The clusters are medium in size; long cylindrical; very loose. The berries are large; much elongated, with one side nearly straight and the other curved, and the ends rounded; pale greenish white to light yellow; neutral in flavor; very low in acid; very tender; thin-skinned and easily

bruised. The stems are very brittle. The vines are vigorous, and moderately productive when cane-pruned. The fruit ripens in midseason.

The Rish Baba does best in the intermediate valley region.

"Eastern" Varieties.—Certain of these varieties, having the Labrusca or "foxy" flavor, are much desired by former residents of the New England and middle western states where these varieties are common. Some can be grown fairly satisfactorily in the cooler parts of the California coastal valleys and mountain areas. Even in favored locations the quality of fruit obtained is inferior to that of the same varieties produced in good locations in the East and Middle West. Their usefulness in California is limited to home gardens and local markets.

Wherever grown they should be trellised, cane-pruned, and irrigated frequently. Being more resistant to powdery mildew than the vinifera grapes, they need be sulfured usually only once or twice each season, often not at all. Otherwise their culture and care is the same as for vinifera varieties.

The best for California planting are black—Concord and Pierce; red—Agawam, Iona, Vergennes, Delaware, and Catawba; white—Niagara and Golden Muscat.

Table-Grape Varieties of Minor Importance.—Of the many other known varieties of table grapes, those listed in table 1, while generally not considered good shipping varieties, do possess qualities that make them suited to home gardens and local markets.

BLACK WINE GRAPES[22]

Zinfandel.—In acreage and total production Zinfandel is the leading wine-grape variety of California. It is of unknown origin and is not grown extensively in any other country. The wine, which has a characteristic flavor, is of medium acidity and color. The variety is best suited to the cooler districts for the production of dry wines, although in the warmer regions it is extensively used in blends for port-type wines. In the hotter districts and particularly in irrigated vineyards it is very susceptible to bunch-rot (black-mold infection).

The clusters are medium-sized; winged cylindrical; and well filled to very compact. The berries are medium-sized; spherical; reddish black to black; juicy in texture. The apical scar is irregularly shaped and slightly

[22] For technical descriptions of certain black wine-grape varieties, with photographs, see: Perelli-Minetti, Joseph. Black juice grape varieties in California. 80 p. Issued by the California Federal-State Inspection Service, Fruits and Vegetables. California Department of Agriculture in coöperation with the U. S. Department of Agriculture Bureau of Agricultural Economics. Sacramento, California. 1929.

depressed. The grapes ripen in early midseason. The vines are moderately vigorous and very productive.

The Zinfandel, though best adapted to the coastal valleys, is also grown extensively in the intermediate valley region. The best dry wines of this variety are made from grapes grown in the cooler regions.

Carignane.—Although of Spanish origin, the Carignane has been grown in the south of France probably since the Twelfth Century. There, as also in Algeria, it is one of the most important varieties. On fertile soils it yields very large crops. It is perhaps the best grape grown in California for the making of bulk red wines. Carignane wines are of medium acidity and color but have usually no striking varietal characteristic. Being very susceptible to powdery mildew, it should not be planted where control of this disease is difficult, as in locations subject to frequent summer fogs.

The clusters are medium-sized; shouldered cylindrical; well filled to compact. The berries are medium-sized; ellipsoidal; black with a heavy blue-gray bloom; and ripen in late midseason. The vines are very vigorous and very productive. The canes are large, semierect to erect in habit of growth.

The Carignane, though extensively grown in nearly all wine-producing districts of the state, is best adapted to fertile soils in the warmer parts of the coastal valleys and in the intermediate valley region. It is not well suited to the hot districts of the San Joaquin Valley.

Alicante Bouschet.—In 1865, Henri Bouschet produced this variety in France by crossing Grenache with Petit Bouschet. The latter is itself a hybrid, produced by Louis Bouschet in 1829 by crossing Aramon with Teinturier. The Grand noir is another one of Louis Bouschet's hybrids. All three of these varieties have red or pink juice and are planted in California, but only the Alicante Bouschet is grown extensively. Wines made from it have no outstanding character of merit. The color, especially in new wines, is intense; the acidity low. In fertile soils the variety is very productive, and it is used particularly for blending with other varieties that may be deficient in color. As the grapes have fair shipping qualities, many are sent to eastern markets.

The clusters are medium-sized; shouldered conical; and well filled to compact. The berries are medium-sized; spherical; brilliant black with a blue-gray bloom; and ripen in late midseason.

The Alicante Bouschet is suited best to fertile soils in the warmer parts of the coastal valleys and in the intermediate valley region.

Petite Sirah.—The variety grown in California under this name is not the Petite Sirah of France but a variety of somewhat obscure origin. In

suitable locations it yields well and is a valuable variety for dry red wine. Wines properly made from it are of good quality, with a distinctive recognizable flavor and moderate acidity. The skins have an abundance of color, and since the color is stable the variety is superior to the Alicante Bouschet in blended bulk wines. In hot regions or hot seasons the fruit may sunburn badly.

The clusters are medium-sized; winged, cylindrical; and compact. The berries are medium-sized; slightly ellipsoidal; black with a dull bluish-gray bloom; and ripen in early midseason. The vines are of moderate vigor and productivity. On dry hillside soils, short spur pruning is satisfactory; but in fertile soils, short cane pruning may be needed.

The Petite Sirah is best adapted to the valleys of the north coast region, where, in the cooler locations, good dry wines may be made from it. It also does very well in the intermediate valley region, where it is used for both dry and sweet blended wines.

Mataro.—Like the Carignane, this variety is of Spanish origin and is of value in California primarily for the production of bulk wines. Mataro wines lack striking varietal characteristics and have medium acidity and color. In most locations the Carignane is preferred because of its greater vigor and higher productivity. The Mataro is, however, less susceptible to powdery mildew than the Carignane, and also starts its buds slightly later in the spring, a characteristic that may be of importance in situations subject to spring frosts.

The clusters are medium large; usually two-shouldered, conical; and compact. The berries are medium-sized; spherical; black with a heavy blue bloom; firm pulpy; and ripen in late midseason. The vines are moderately vigorous; erect in habit of growth; and moderately productive.

The Mataro appears adapted to the south coast region and to the low foothill districts on the east side of the lower Sacramento Valley. It should not be planted in the cooler districts.

Cabernet Sauvignon.—The famous claret wines of the Gironde region of France derive their flavor and character from this variety. In suitable locations in California it produces a wine of pronounced varietal flavor, high acidity, and good color; and it is one of our finest dry-red wine varieties.

The clusters are small to medium in size, irregular in shape but often long conical; and loose to well filled. The berries are small; very seedy; nearly spherical; black with a gray bloom; and ripen in midseason. The skin is tough; the flavor rather pronounced and characteristic. The vines

are very vigorous but not very productive. For satisfactory crops in some situations, long spur or cane pruning may be required.

It is best adapted to the cooler coastal valleys where the grapes attain their highest quality.

Grenache.—This Spanish variety is grown in California largely for the production of port-type wine, to which it is well suited. It thrives in

TABLE 2

IMPORANT RED-WINE GRAPE VARIETIES NOT EXTENSIVELY GROWN IN CALIFORNIA*

Variety	Period of maturity	Acidity	Intensity of color	Productivity	Kind of wine usually produced
Aleatico	Early	Medium	Low	Medium	Sweet, muscat
Alicante Ganzin	Medium	Medium	Very high	Medium	Blending, color
Aramon	Late	Medium	Low	High	Dry, table
Beclan	Medium	Low	Medium	Low	Dry, table
Barbera	Medium	High	Medium	Medium	Dry, varietal
Black Prince	Medium	Low	Low	High	Sweet
Charbono	Late	Medium	High	Medium	Dry, table
Fresia	Early	High	Medium	Low	Dry, varietal
Grand noir	Medium	Medium	High	Medium	Dry, table
Grignolino	Early	High	Low	Medium	Dry, varietal
Gros Manzenc	Late	High	High	Medium	Dry, table
Lagrain	Early	Medium	High	Medium	Dry, table
Malbec	Early	Medium	Medium	Medium	Dry, table
Mondeuse	Late	Medium	High	Medium	Dry, table
Mourisco preto	Medium	Medium	Medium	Medium	Sweet
Nebbiolo	Medium	High	Medium	Medium	Dry, table
Pagadebito	Late	Medium	High	Medium	Dry, table
Petit Bouschet	Medium	Low	High	Medium	Dry, table
Pinot noir	Early	High	Medium	Low	Dry, varietal
Refosco	Medium	Medium	High	Medium	Dry, table
Salvador	Early	High	Very high	Low	Blending, color
Sangioveto	Medium	High	Medium	Medium	Dry, table
Saint Macaire	Medium	Medium	High	Medium	Dry, table
Tannat	Early	High	High	Medium	Dry, varietal
Tinta amarella	Medium	Low	Medium	Medium	Sweet
Tinta Madeira	Early	Low	Medium	Medium	Sweet
Trousseau	Early	Low	Low	High	Sweet
Valdepenas	Early	Medium	Medium	High	Dry, table

*The values assigned are only relative and will vary with environmental conditions. In the right-hand column, "table" refers to a wine of no particular recognizable varietal characteristic; no other indication of quality is intended. "Varietal" refers to a wine having a particular flavor or other character recognizable as having been imparted to the wine by the particular variety of grapes.

the hot regions, bearing excellent crops. Its wines are medium low in acidity, and in many locations are somewhat deficient in color and must be blended with other varieties that have more abundant color. The vines are very susceptible to powdery mildew.

The clusters are medium-sized; short conical, sometimes shouldered or winged; and loose to well filled. The berries are small medium; short ellipsoidal, nearly spherical; reddish-purple to black; and ripen in mid-season. The stems of the clusters are very thick. The vines are very vigorous, erect in habit of growth, and very productive.

The Grenache is probably best adapted to the hot, sweet-wine-producing regions such as the San Joaquin and Sacramento valleys. It may deserve further trial as a constituent for dry wines in some of the coastal valleys.

Mission.—The Jesuit missionaries planted the first vinifera grapes in California at the San Diego Mission in the latter part of the Eighteenth Century. The variety was apparently the Mission and, until about 1870, the principal variety grown in California. Since then it has been gradually displaced by other varieties in the coastal regions and is now grown mainly in the warmer valleys, where it is valuable as a sweet-wine grape. It has always been associated with the making of sweet, white wines such as Angelica. It is low in acidity and too deficient in color to be used alone for red wines.

The clusters are large; conical, but heavily shouldered; and stiffly loose—stems sufficiently rigid to cause the individual berries to stand apart. The berries are medium-sized; spherical; reddish purple to black; ripening in late midseason. The pulp is firm but juicy. The vines are very vigorous, and single vines occasionally attain enormous size. Given room to develop, Mission bears heavily; but if it is crowded or pruned too short, the crops tend to be irregular.

This variety is best adapted to the San Joaquin and Sacramento valleys and the south coast region.

Malvoisie (*Cinsaut*).—This heavy-producing variety appears to have been imported from the south of France. It is used in California principally for blending with other varieties in making sweet wines. It is low in acidity, low medium in color, and attains a very high sugar content before starting to raisin.

The clusters are medium-sized; winged cylindrical; and loose to well filled. The berries are medium large; ellipsoidal; reddish black to black. They ripen in early midseason and lose water rapidly after removal from the vine, so that they soon become soft after picking. The vines are vigorous and productive.

Other Red-Wine Grapes.—Many of the world's most important red-wine grape varieties are not included in the foregoing descriptions because they are not grown extensively in California. Very brief notes on certain of them are given in table 2.

WHITE WINE GRAPES

Palomino.—In certain parts of California this variety is erroneously called Golden Chasselas. It is the principal sherry grape of Jerez (Spain). Being widely adaptable to soils and climates, it thrives in

nearly all wine-grape-producing districts of the state. Used alone, it makes only a mediocre natural dry wine, mainly because it is low in acidity. There can be little doubt that it is best suited to the production of sherry.

The clusters are large-medium in size; shouldered and widely branched; stiffly loose to well filled. The berries are medium; oblate; greenish yellow with a heavy white bloom; firm to somewhat tough; and ripen in midseason. The vines are very vigorous and very productive. The leaves are dull, dark green in color, rough on the upper surface, with a heavy, tufted pubescence on the lower surface.

The Palomino, though also adapted to the coastal valleys, is particularly well suited to the San Joaquin, Sacramento, and intermediate valley regions.

Burger.—Where the soil is fertile and the climate warm, the Burger produces enormous crops. In cool locations it does not ripen well, and early rains may cause much damage from bunch rot. In the warmer parts of the coastal valleys it produces a light wine of mediocre quality. In the south coast and the intermediate valley regions it ripens better and gives heavier yields. Its primary usefulness is in the production of cheap bulk wines. When fully ripe the grapes are low in acidity.

The clusters are large medium in size; shouldered to winged cylindrical; and compact. The berries are medium-sized; spherical; whitish yellow; very juicy; soft; and late-ripening. The vines are vigorous and highly productive.

The Burger is best suited to warm situations in the coastal valleys and to the intermediate valley region.

Sauvignon Vert.—The origin and true name of the variety grown in California under this name is obscure. It is not the Sauvignon vert of France, but may be the variety grown there as Muscadelle du Bordelais and used to a limited extent for blending with Semillon in making wines of the Sauternes. Its wine has moderate varietal flavor and aroma, but is said to be low in acid and not to keep well unless blended with other varieties. In frosty situations the Sauvignon vert often bears better than many others.

The clusters are small to medium; cylindrical; loose to well filled. The berries are small medium; short ellipsoidal; greenish yellow; soft in texture; juicy; thin -skinned; and ripen in midseason. The vines are vigorous, semiupright in habit of growth, and productive.

The Sauvignon vert is best suited to the valleys of the north coast region.

Semillon.—The world-famous Sauternes wines of France largely owe their character to the Semillon grapes used in them. This variety, one of the truly fine wine grapes of the world, happily does very well in certain parts of California. Here, however, because of the dryness of our climate, we do not have the "noble rot" (*Botrytis cinerea*) working on the grapes as they ripen; hence the finished wines differ from the French Sauternes in flavor and aroma.

The clusters are small to medium in size; short conical; well filled. The berries are medium-sized; spherical; golden yellow; sprightly and aromatic in flavor. They ripen in midseason. The vines are vigorous and moderately productive.

The Semillon is best suited to the north coast region.

Sauvignon Blanc.—Next to the Semillon this is the most important variety of the Sauternes. Used alone it makes a fine wine of pronounced character, but the blend with Semillon is usually considered superior to the wine of either variety used alone.

The clusters are small to very small; conical; and very loose. The berries are small; spherical; whitish yellow; and ripen in midseason. The vines, though vigorous, are usually shy-bearing.

The Sauvignon blanc is best suited to the north coast region.

Johannisberger Riesling (*White Riesling.*)—The Rhine wines of Germany are made principally from this variety. Its wines possess a strong varietal flavor and bouquet, and the other constituents harmonize well.

The clusters are small; cylindrical; well filled. The berries are medium-sized; spherical; greenish yellow, speckled with brown russet dots; sprightly, somewhat aromatic in flavor; juicy. They ripen in early midseason. The vines are vigorous and moderately productive with long pruning.

This variety is suited only to the coolest situations of the north coast region.

Franken Riesling (*Sylvaner*).—This, the principal Rhine-wine type grown in California, endures more warmth than the Johannisberger. The wine is of good character.

The clusters are shouldered conical and compact; the berries whitish yellow. Otherwise the grapes closely resemble the Johannisberger in appearance.

The variety is suited only to the north coast region.

Green Hungarian.—The vines are very vigorous and very productive. It produces a light, neutral wine which lacks character and is suited best for blending in the making of cheap bulk wines.

The clusters are large; shouldered cylindrical; and compact. The ber-

ries are medium to large; spherical; light green; soft juicy in texture. They ripen in midseason.

This variety is adapted to the intermediate valley region and the coastal valleys.

Feher Szagos.—In the sweet-wine-producing districts this highly productive variety finds a place because it makes a good sherry.

The clusters are medium to large; shouldered cylindrical; and well

TABLE 3
IMPORTANT WHITE-WINE GRAPE VARIETIES NOT EXTENSIVELY GROWN IN CALIFORNIA*

Variety	Period of maturity	Acidity	Productivity	Kind of wine usually produced
Boal de Madeira	Medium	Medium	High	Sweet
Chasselas doré	Early	Low	Medium	Dry, table
Clairette blanche	Medium	Medium	High	Dry, table
Folle blanche	Late	High	Medium	Dry, table
Gray Riesling	Medium	Medium	High	Dry, table
Inzolia	Late	Low	High	Sweet
Kleinberger	Medium	Medium	Medium	Dry, table
Muscat Canelli	Early	Medium	Low	Sweet, varietal
Peverela	Medium	Medium	Medium	Dry, table
Pinot blanc	Early	High	Medium	Dry, varietal
Roussette	Late	Low	Medium	Dry, table
Saint Emilion	Late	Medium	Medium	Dry, table
Vernaccia Sarda	Medium	Medium	High	Sweet, table

*The values assigned are relative only and will vary with environmental conditions. In the right-hand column, "table" refers to a wine of no particular recognizable varietal characteristic; no other indication of quality is intended. "Varietal" refers to a wine having a particular flavor or other character recognizable as having been imparted to the wine by the particular variety of grapes.

filled. The berries are large; elongated ellipsoidal; greenish yellow; soft juicy and very tender in texture; and ripen late. The vines are very vigorous and highly productive. The fruit is extremely susceptible to bunch rot.

This variety appears best adapted to the San Joaquin Valley.

Other White-Wine Grapes.—Certain additional varieties of white-wine grapes, important in other countries but not extensively grown in California, are given in table 3.